DELFT OUTLOOK
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TU Delft

Professor of Excellence Jenny Dankelman

'Technical innovations take time'

KAUMERA

Lucky find becomes top material

Aircraft of the future?

Flying-V, a tailless plane

THEME

Underground

Cover:
You don't have to look far to find an underground project at TU Delft. There's a geothermal heating duct underneath the whole of the TU Delft Campus heating buildings from one central point. This now contains other cables as well. A cable inspection provides a wonderful opportunity to see what's going on underground. (Photographer Sam Rentmeester)

Foreword
Tim van der Hagen

Underground

Whereas the last edition of Delft Outlook was all about space, this one takes us underground – which is where a lot is happening in terms of research. Applied Earth Sciences students Claire Mulder and Frederikke Hansen went quite CSI at the forensic cemetery in Amsterdam as they investigated whether, and how, a body can be located underground.
Ramon Hanssen's research into subsidence in the Netherlands might not be quite as exotic, but it certainly is just as exciting: an interactive subsidence map of the Netherlands shows that all of Holland is subsiding, and even faster than we had previously thought. In addition to known causes such as gas extraction, climate change also seems to be involved here.
I fully agree with Timo Heimovaara's view that subterranean capacity should be optimally used for the benefit of society. We can now apply the knowledge acquired in research into oil and gas extraction to arrive at environmentally friendly applications, such as geothermal energy. As always, I am of the opinion that we as TU Delft should set a good example, which is what we will be doing with the planned geothermal well on campus. Besides providing sustainable heating for our buildings, it will serve as a geothermal research well.
A number of students had suggested a well like this as far back as 2008, but as the latest recipient of the Professor of Excellence Award Jenny Dankelman says: "Technical innovation takes time. You have to have the patience for this." Meanwhile our campus is also developing at a steady rate above ground; read more about this later on in this issue.

Professor Tim van der Hagen, President Executive Board

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Underground

PHOTO: SAM RENTMEESTER

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DELFT IN BRIEF

Photo: Filip Meysman

Electric bacteria

Bacteria in the sludge in the Western Scheldt can conduct electricity. Thousands of bacteria lace themselves together to form a fine thread a few centimetres long. Prof. Filip Meysman and Prof. Herre van der Zant and their team presented these findings in an article in Nature Communications (11/09/2019). This previously unobserved behaviour allows sludge bacteria, which live off the oxidation of sulphides, to expand their habitat.

Solar Boat wins at sea

Illustration: Solar Boat Team

This summer, the TU Delft Solar Boat Team won the Offshore Class in Monaco. The students developed a boat that could go out to sea. The 8x6m trimaran, equipped with 28m2 of solar cells, reached a top speed of 35km/h between Monaco and Ventimiglia. On the second day the team had to disconnect the solar cells due to a fire risk and run on battery power, which required a more cautious approach. The team previously suffered a damaged hydrofoil.

Exhibition in 'De Gist'

This autumn, the old office building of the Dutch yeast and methylated spirits factory is the location for two free exhibitions. Life Science & Technology students will be on hand to provide more information. The pop-up experience includes the historical exhibition 150 years of yeast and the futurist Artis-Micropia exhibition Small life, big impact, which introduces visitors to microbes and their benefits. Both are running until 14 December.
For more information, see 150jaargist.nl/en

Birth of galaxies

The birth of galaxies – that is what Delft researchers hope to see using Deshima, the instrument they helped to develop. It contains a chip that measures dozens of shades of far-infrared light. The team is led by astronomer Dr Akira Endo (Applied Sciences). He and his colleagues have linked the instrument to the Japanese Aste telescope in Chile. They want to measure the distances and ages of distant galaxies by looking at the Doppler effect of light. The redder the light, the higher the speed and the further away the galaxy. The light from the fastest, furthest galaxies can be seen on Earth as far-infrared light. An initial test showed that the technology works.

Rivers in straitjackets

It's a sorry state of affairs for the Earth's rivers. An international team of scientists examined 12 million kilometres of rivers on all continents. Of the 246 longest rivers, only about a third still flows freely into the sea, the team wrote this summer in Nature. The rest has been pressed into straitjackets through dams and locks. One of the authors is hydrologist Michael McClain (CEG). "Free-flowing rivers are vital for healthy fish stocks and for transporting sediment to deltas," says McClain. "Without this sediment transport, delta regions are in danger of falling prey to rising sea levels even more quickly."

Frontline observation post

Delft researchers from the micro aerial vehicle laboratory (MAV lab) are working on a drone that can take off and land from a rocking ship at sea. With twelve propellers, four wings and a wingspan of more than two metres, it is intended to be used as a frontline observation post for naval vessels. The drone will have a hydrogen fuel cell that will allow it to fly dozens of kilometres, far beyond the Navy's radar monitoring area. Drones are nothing new, of course, but using them at sea is. Salt deposits, corrosion, weather and magnetic fields affect the operation of drones – challenges aplenty in a maritime environment!

EEMCS renovating the high-voltage lab

EEMCS' cathedral-like high-voltage lab is currently closed for renovations. The building, which will be renamed the Electrical Sustainable Power (ESP) lab, will be reopened in 2021. This lab will be home to the entire chain of sustainable electricity, from solar cells and charging stations to smart grids and transport networks. According to Prof. Miro Zeman, head of the electrical sustainable engineering department, the ESP lab is the Faculty's answer to the challenges facing the electricity sector in the 21st century, during which coal and gas-fired power stations will make way for sustainable sources. This project is supported by TenneT, the transmission system operator.

Illustration: ESP-lab

Ruling on nitrogen and housing construction

The Council of State's ruling on nitrogen threatens to have a disastrous effect on road and housing construction. Do Delft researchers have any potential solutions? Professor of the housing market Peter Boelhouwer would like to see agricultural land area reduced by 20%. Microbiologist Dr Henk Jonkers, materials researcher at CEG, wants an integrated approach to housing and air quality with more green areas in neighbourhoods. Prof. Rogier Wolfert thinks that by combining construction activities in a smarter way, disruption in cities can be reduced.

Photo: Sam Rentmeester

Twenty years of Nuna

The first Nuna in 1999.

Two TU Delft students dreamt of participating in the World Solar Challenge, a 3000km journey from Adelaide to Darwin. In 1999 they built the very first Dutch solar-powered vehicle. Sponsored by Nuon and supported by Wubbo Ockels, the student team won gold. More than 20 years later, another Delft solar-powered vehicle will be hitting the Australian roads. From 13 October, this team hopes to win its 8th world title with the NunaX, the 10th in the series.

The NunaX in 2019. (Photo's: Vattenfall Solar Team)

Recycling concrete

Concrete production accounts for 5-10% of global CO_2 emissions. For professor of recycling Peter Rem (CEG), this was one of the main reasons for developing an installation that converts concrete back to gravel, sand and cement. In collaboration with construction company Strukton, he developed a mobile concrete crusher that grinds concrete into grit with a rapidly rotating rotor (Advanced Dry Recovery). TU Delft TV made a video about it.

THEME
Underground

It is dark underground, but the topics this theme covers are certainly not. Researchers from Delft have discovered that earthquakes can be mapped by analysing infrasound from the atmosphere. Their discovery could save lives. And the proposal for underground gas storage in geological formations has won Dr Hadi Hajibeygi a Vidi research grant from the Dutch Research Council (NWO). Illustrator Stephan Timmers drew an illuminating illustration to a story about the Delft Geothermal Project which will be supplying heat to the campus and its environs. And the students on this photo investigated how you can locate a body underground using their scanner. This and more in the 'Underground' theme.

PHOTO: SAM RENTMEESTER

How **Shell** and **Delft** found each other

What would have become of TU Delft without Koninklijke Olie/Shell? The largest company in the Netherlands has always had an impact on technical education and research. Perhaps more so than any other company. But let's not exaggerate its role.

After the secession from Belgium in 1830, the Kingdom of the Netherlands had a lack of geological knowledge. Not too much of a problem, because the Dutch subsoil consisted of fine-grained clay with the occasional layer of sand. Not particularly useful. Mining was taught in Delft in the 19th century, but only a handful of reckless people chose to do it as the career prospects were searching for ore deposits or other exploratory work in the jungle of the Dutch East Indies. Many engineers did not survive to tell the tale.

One of those reckless people was Adriaan Stoop. Around 1880, when looking for water in East Java, he came across oil on several occasions. In 1887 Stoop founded the Dordtsche Petroleummaatschappij, three years before Koninklijke Olie. In 1911, the two companies merged. Anyone who has seen the film There Will Be Blood knows that oil extraction in those pioneering years was a question of luck and ruthlessness. This was also reflected in the company's history, which Shell documented in 2007.

The same study also showed that the Dutch oil company was one of the first to realise that technology was crucial for long-term success. Delft engineers played a key role in this vision and have always held leading positions in the company. In a way, you could say that 'Delft' left a bigger mark on Shell than the other way around.

Shell's influence on education and research in Delft, on the other hand, only really started after the Second World War. In order to build up industry in the post-war period, two additional technical colleges were created to provide the business community with knowledge and engineers. Delft retained a monopoly on mining studies and there was only one large Dutch company that took on graduates, especially when the mines in Limburg had been exhausted.

CAREER PATH

Formal agreements weren't even required to enter into partnerships. If you studied mining and oil extraction in Delft, you almost certainly went on to work at Koninklijke Olie. Later in your career, you might have returned to Delft to train new engineers or to do research that was just a little more fundamental than at Shell's R&D labs, a few kilometres away in Rijswijk. Delft graduates in chemical technology, process technology and technical physics also had a similar career path.

A well-known example is Guus Berkhout, who obtained his PhD in signal processing in 1970, worked for Shell for several years and eventually returned to the university. As a professor of acoustics, he successfully acquired funding from Shell in the 1980s and 1990s to investigate whether sound waves could be used to detect oil fields. Before that, he also founded the Delphi Consortium, an alliance of oil companies that supported

Photo: Wikipedia

The board of the Dordtse Petroleummaatschappij in 1896. The company was founded by Adriaan Stoop (right on photo) and merged with Koninklijke Olie in 1911.

his research. Berkhout has now retired, but Delphi still finances more than 20 PhD students and postdocs.

NO LONGER A GIVEN

Since the year 2000, this relationship has changed. Shell now also has research centres in Houston and Bangalore. It recruits internationally. A degree from Delft no longer automatically leads to a job at a Dutch company. In fact, Shell is falling on the list of favourite companies to work for, mainly because of its poor sustainability reputation.

When it is no longer a given that two parties will choose each other, commitments are all the more remarkable. In 2011, TU Delft and Shell formally declared each other to be 'preferred partners'. The agreement meant that for five years, Shell invested four million euros a year in the university – for research in geophysics, process technology, fluid dynamics and oil extraction. Of course, the fact that this formal agreement has come to an end does not mean that this relationship has ended. For example, a former beneficiary, Hans Geerlings, is still a professor at Delft one day a week and a researcher at Shell on the other four days. His work focuses on carbon-neutral fuels, such as hydrogen.

A shift towards sustainability followed in the spring of 2019, with an agreement to work on technologies to reduce emissions in the petrochemical industry. Although a lot of oil research is still being done, including through the Delphi Consortium, the tide is turning in Delft. In September, the university decided to discontinue its Master's programme in petroleum engineering.

The sources that were used in the creation of this article are on tudelft.nl/delft-integraal

Locating bodies

Searching for firearms or human remains metres underground is easier said than done.

Everyone has a general idea of how to go about finding weapons. But how do you search for human remains in hard clay soil? Students Claire Mulder and Frederikke Hansen (Applied earth sciences) know how it's done. They used various scanning and measuring techniques, to find out if and how you can locate a body underground.

The research (for their Bachelor's graduation project) was carried out at two totally different locations: the TU Delft campus and Amsterdam Medical Centre's (AMC) forensic cemetery. They mapped these areas using a device equipped with electrical resistivity tomography (ERT) and a ground-penetrating radar (GPR). The GPR was used to create two-dimensional images, so-called radargrams, which show reflections in the ground. Using the ERT required more effort. "For this we had to put 100 steel pins in the ground," Mulder explains. "Using a certain pattern, you then send current into the ground and measure the resistance of the ground."

Mulder and Hansen started by scanning the ground behind the Faculty of Civil Engineering and Geosciences. "We were looking for two barrels that had been buried there in 2018 for another graduation project," explains Hansen. "It happened so spontaneously that the university didn't even know about it. The students even lost the coordinates of those barrels," laughs Hansen.

Luckily, the two quickly located the barrels and the real work in Amsterdam beckoned. Three bodies are buried in the forensic cemetery, the first and only one of its kind in Europe. There is also an empty grave. A unique location, not least because Mulder and Hansen's research was the first of its kind to be conducted on Dutch soil. "There are very few places like this in the world," Hansen explains. "Researchers normally use pigs, but the fat content, enzymes and chemicals present in pig carcasses are not the same as those in human remains."

Setback

This scientific first was not without considerable challenges. Since the forensic cemetery

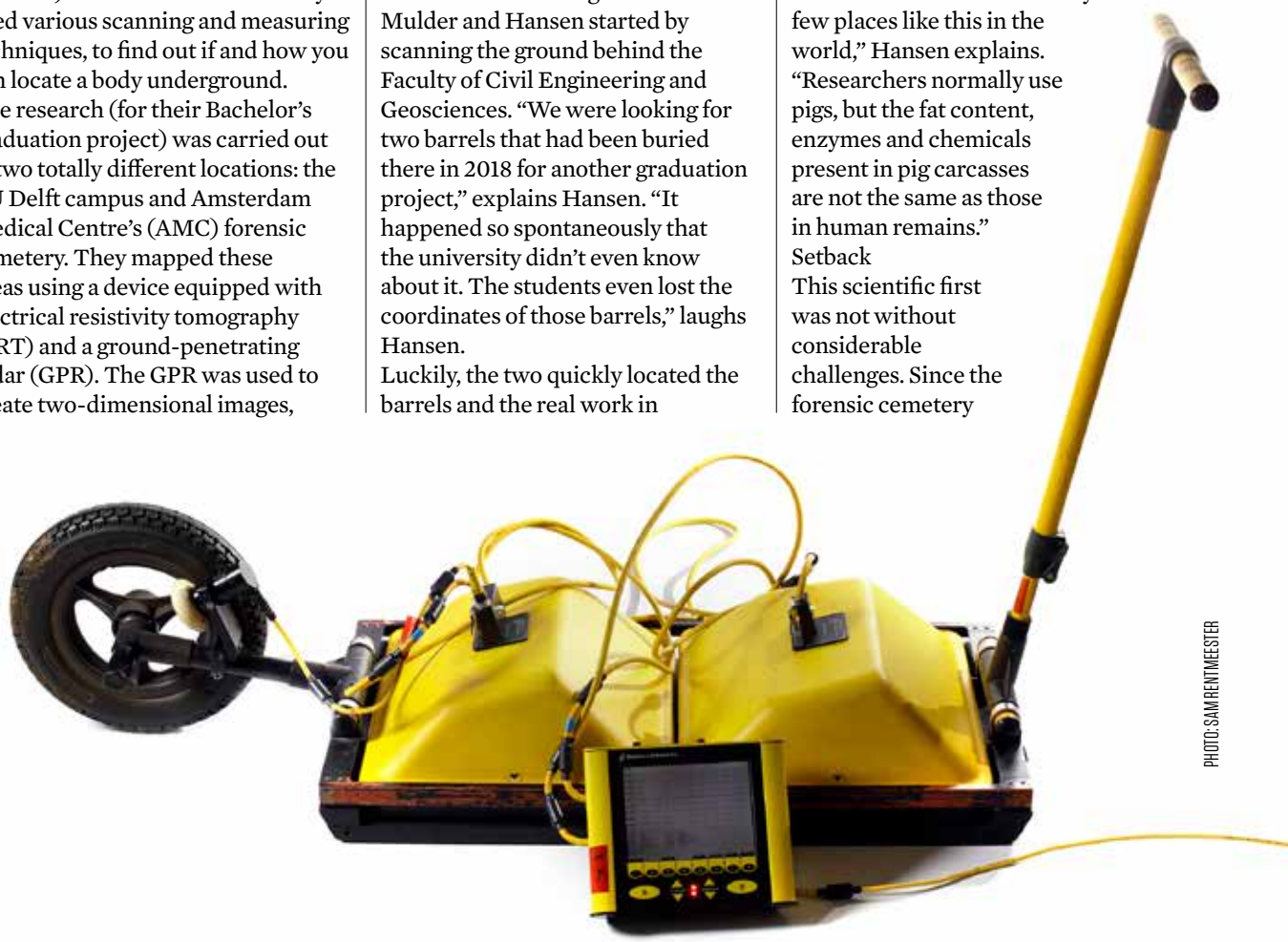


PHOTO: SAM RENTMEESTER

only opened last year, little thought had been given to the type of experiments that could be carried out here. Hansen: "The two graves we were investigating were right next to a metal fence. Metal interferes with the signals from the GPR, so we couldn't use those

'This is valuable information for the police. They can dig in a specific location rather than dig up entire areas'

results." But it was precisely this information that proved useful. "Now they know not to bury bodies near a fence in the future."
The students also observed differences between soil where there was a body and soil where there was no body. "This is valuable information for the police. They can dig in a specific location rather than dig up entire areas," says Mulder. MvdV

Frederikke Hansen and Claire Mulder (Civil Engineering and Geosciences) wrote individual theses on their findings. Hansen focused on the use of GPR methods for forensic research, Mulder on the use of ERT. The Bachelor's graduation project was the result of a collaboration between TU Delft and the Netherlands Forensic Institute.

How undertows are threatening dykes

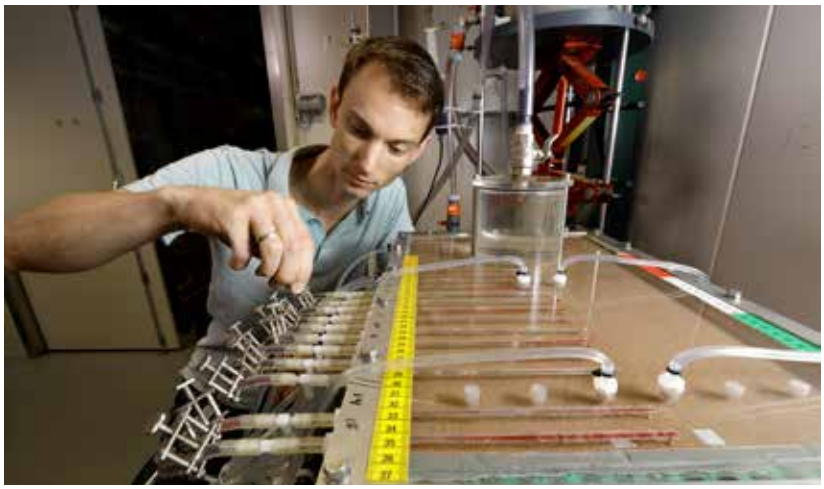


PHOTO: SAM RENTMEESTER

It's every dyke-reeve's nightmare. After a week of high water, a river dyke suddenly collapses and water bursts through. How can this happen? At Deltares, PhD candidate Joost Pol is investigating how undertow affects dykes.

A clay dyke may seem solid, but if it was built on a sandy riverbed and the water level rises, so too does the water pressure under the dyke. One small crack in the clay could be the beginning of a leak. On the inside of the dyke, deep in the polder, this appears as a mound of sand bubbling up from the bottom. Experts talk about piping as a dreaded failure mechanism in river dykes. Because what starts out as a tiny stream develops into a channel (pipe) of water undermining the dyke, resulting in an exponentially accelerated rate of erosion. The sand is washed away and the dyke collapses. How quickly does this happen and what factors are involved?
In the geophysical laboratory at Deltares, Joost Pol simulates the piping process in a layer of sand under a Perspex plate. A row of tubes measures the local pressure and a camera above films the experiment. It records the formation of channels a few centimetres wide and a few millimetres deep that grow at about half a metre per hour. When such a channel expands all the way under the dyke and reaches the river, the process suddenly speeds up because the water is unimpeded.
Halfway through his PhD project, Pol discovered that the speed at which the channel expands depends on the properties of the sand and the current. "The coarser the sand and the higher the water pressure, the faster the channel expands," he summarises.
Pol is creating a numerical model to simulate the process. By doing so, he wants to integrate his research results in a risk analysis for river dykes. Previous research has shown that three quarters of river dykes need to be reinforced. If we know which places are most at risk, we can use a much more efficient approach to dyke reinforcement. JW

Storing radioactive waste safely underground

Dutch radioactive waste can be safely stored deep in layers of clay and rock salt. This will not result in long-term radiation hazards for humans. This was the main conclusion of the Opera research programme, which came to an end last year and in which TU Delft participated. The seven-year research project was coordinated by radioactive waste organisation Covra. Assistant professor Phil Vardon and Dr Patrick Arnold (both CEG) used computer simulations to see how layers of clay would behave if the ground was warmed up by the radioactive material. Only in 2130 will the radioactive waste stored at Covra (in Borssele) be definitively disposed of deep in the earth. This final disposal is designed to last for at least one hundred thousand years. By 2130 the Netherlands is expected to have over 170,000 barrels of nuclear waste, 1,200 barrels of which are highly radioactive. TvD

PHOTO: SAM RENTMEESTER

Subsidence in the Netherlands

Researchers headed by Prof. Ramon Hanssen (CEG) have developed an interactive map showing subsidence in the Netherlands.

The scientists incorporated three different types of measurement data into the underlying model: satellite radars, GPS and gravity measurements.
The map shows the different types of soil in the Netherlands and the location of oil and gas fields. This makes it easy to see the causes of the subsidence observed. The map is kept up-to-date using the latest satellite data released on a daily basis, so we can see whether subsidence decreases if less gas is extracted in Groningen.
The map has enabled researchers to distinguish between the deep causes of subsidence, such as gas extraction, and the effects in the uppermost few metres. Until now, it was not possible to directly measure this top layer. It turns out that this 'shallow' subsidence is even greater in some places in the Netherlands than the more familiar, deep causes. This subsidence is particularly measurable in the peat and clay areas in the western Netherlands. Climate change appears to play a major role in this accelerated subsidence.

PHOTO: SAM RENTMEESTER

Subsidence in Kanis.

The relatively warm summers cause more dehydration of the peat soils, speeding up subsidence. This process is irreversible: the peat oxidises, which also means that more CO_2 is released into the atmosphere. TvD

bodemdalingskaart.nl

Predicting earthquakes

Earthquakes can be charted by analysing infrasound high in the atmosphere, or so Delft researchers found. Their discovery could save lives.

On 12 January 2010, a magnitude seven earthquake devastated Haiti. It took days before the extent of the damage was understood, partly because there were no seismometers in the region at the time of the earthquake.
Delft researchers have found a way to circumvent this problem if future disasters like this occur. They are able to pick up acoustic signals – also called infrasound – in the atmosphere caused by earthquakes.
"Some of the energy caused by earthquakes leaks into the atmosphere," says seismic expert Dr Shahar Shani-Kadmiel of the Geoscience and Engineering Department (CEG faculty). "Even if there are no seismic stations anywhere near the epicentre, you can still pick up the signals in the atmosphere thousands of kilometres away and use these to reconstruct a shakemap, which indicates the distribution of shaking intensity."
The mathematical model that explains how this energy leaks into the atmosphere has been known for over a century. But until now it was impossible to filter out the faint waves from the background noise in the atmosphere with pressure sensors (barometers).
"Now we can do this because we have had plenty of data to improve our algorithms and calibrate the models," says Shani-Kadmiel. "Many of these data come from submarine volcanic eruptions. Another important source was the underground nuclear test that North Korea carried out on 3 September 2017 at Punggye-ri, in the north east of the country. This was a much bigger explosion than the ones in the preceding years. It was the equivalent of a magnitude six earthquake."
The research was carried out in the framework of the Comprehensive Nuclear-Test-Ban Treaty. The leader of the project, Prof. Läslo Evers (CEG Faculty), is also employed by the Royal Netherlands Meteorological Institute KNMI which surveys the international ban on nuclear tests.
The Delft researchers used the new insights on the wave propagation to ameliorate their shakemap algorithms for earthquakes. An article about how they reconstructed the shakemap of the 2010 Haiti disaster has been submitted to Nature as a proof-of-concept. TvD

Online learning

TU Delft Online Education pays close attention to new, more sustainable modes of transportation. For this reason, we have now launched two online courses which may shake, improve and enhance the current practices in the underground transportation systems.

Hyperloop: Changing the Future of Transportation

Is a passenger pod levitating in a vacuum tube a viable alternative to current modes of transport? Join TU Delft's groundbreaking MOOC to find out. This course was designed by the Hyperloop Dream Team, which consist of winners of the SpaceX Hyperloop Pod Competition 2017. This course development team also holds the trophy of Excellence in the Open Education Awards 2019.
Imagine traveling as fast as an airplane with the ease and energy of a train system. Hyperloop tunnels would offer many interesting possibilities for passengers transport. People could travel faster and in a more sustainable manner. This mode of transportation would also offer a possibility for new transportation of resources such as gas, water or electricity. The tubes could travel either above or below the surface, which unlocks different building options depending on the regions' needs.
Hyperloop will require some significant effort to become viable. Technological and political challenges need to be solved before this mode of transportation becomes a reality. We welcome all new learners to join this course and contribute to a more sustainable and more connected world.

Starts February 5th 2020

edx.org/course/hyperloop-changing-the-future-of-transportation-2

Railway Engineering: Design, Operations and Performance

To keep trains running, improve services over time and offer faster and more comfortable travel, the rail industry is in need of the knowledge and skills to support innovation and provide sustainable and low-cost solutions. This entails the smart use of resources and the ability to meet the demands and requirements of all stakeholders involved. To do this successfully, experts need to master their own area of specialization, but also be able to understand railway operations from a broader systems perspective. Through understanding how all the interfaces relate, affect each other and influence the system, professionals can deploy more efficient ways of planning and implementing operational and maintenance strategies. This will ultimately have an impact on their decisions about investment, innovation, and optimization.
Our online program in Railway Engineering consists of 3 career-oriented courses plus a capstone project. It is a highly practical program that provides rail professionals with the appropriate tools and valuable insights in how to adopt this new systems approach to railway engineering and operations.

Starts March 2020

online-learning.tudelft.nl/programs/railway-engineering

To get the full picture please visit: online-learning.tudelft.nl

Underground storage of green gas

A fully sustainable energy system needs large-scale energy storage. Dr Hadi Hajibeygi's proposal for storing green gas in geological formations has won him a Vidi grant from the Dutch research fund NWO.

PHOTO: TAQA

The gas reservoir Bergermeer in Alkmaar.

"I offer a data-informed simulation method for the safe use of underground formations for the cyclic injecting and producing of green fuels," Hajibeygi promises in his research proposal ADMIRE (stands for Adaptive Dynamic Multiscale Integrated Reservoir Earth simulation method) to NWO. His research expertise is underground fluid dynamics. What looks like impenetrable rock to laymen, is the domain of subsoil streams of gas, oil and water to him. 'Life is porous' is his motto.

Underground gas fields are an option for storing renewable energy for months.

"We measure capacity in terawatt hours (TWh = 1012 Watthour)," says Hajibeygi. "That is the order of magnitude of a national energy storage – 10 million times more than the capacity of a brand new car battery." For comparison, energy consumption in the Netherlands is about 800 TWh per year.

There is experience with the underground storage of gas, says the Vidi laureate. He mentions the Bergermeer gas reservoir near Alkmaar, which has been used for the commercial seasonal storage of methane since 2014. Elsewhere, hydrogen has been stored in salt caverns. This often involves high pressure (up to 200 bar). In comparison with green methane, hydrogen flows much more easily in porous rocks. While the chance of leakage is higher, the conversions are more direct. A surplus of renewable electricity produces hydrogen by hydrolysis. Hydrogen can be converted back into electricity by a gas engine or a fuel cell. The round-trip efficiency is currently about 40%.

'We need to choose wisely where to store it'

Underground gas storage depends on how the gas flows through the pore spaces in rocks and through the reservoir. Hajibeygi studies these flows by coupling laboratory measurements with large-scale simulations (at kilometre scale with centimetre resolution) and seismic field measurements. His goal is to find suitable locations and safe operational procedures for underground gas storage.

How does he think local people will react to the idea of repeatedly injecting and producing gas from under their feet? "We need to choose wisely where to store it," says Hajibeygi. "Therefore we need to map, predict and monitor the flow of green gas and the properties of the earth layers."

In Alkmaar, people initially feared earthquakes when the gas storage was planned, but since the facility is in use, KNMI, the royal meteorological institute, has hardly registered any significant seismic activity.

The ADMIRE project's first PhD candidate will start soon. Next year, another PhD and a postdoc will follow. With this team, and in collaboration with research labs and universities in Germany, the Netherlands and the United States, Hajibeygi aims to couple modelling and monitoring to reduce the uncertainties about green gas storage. JW

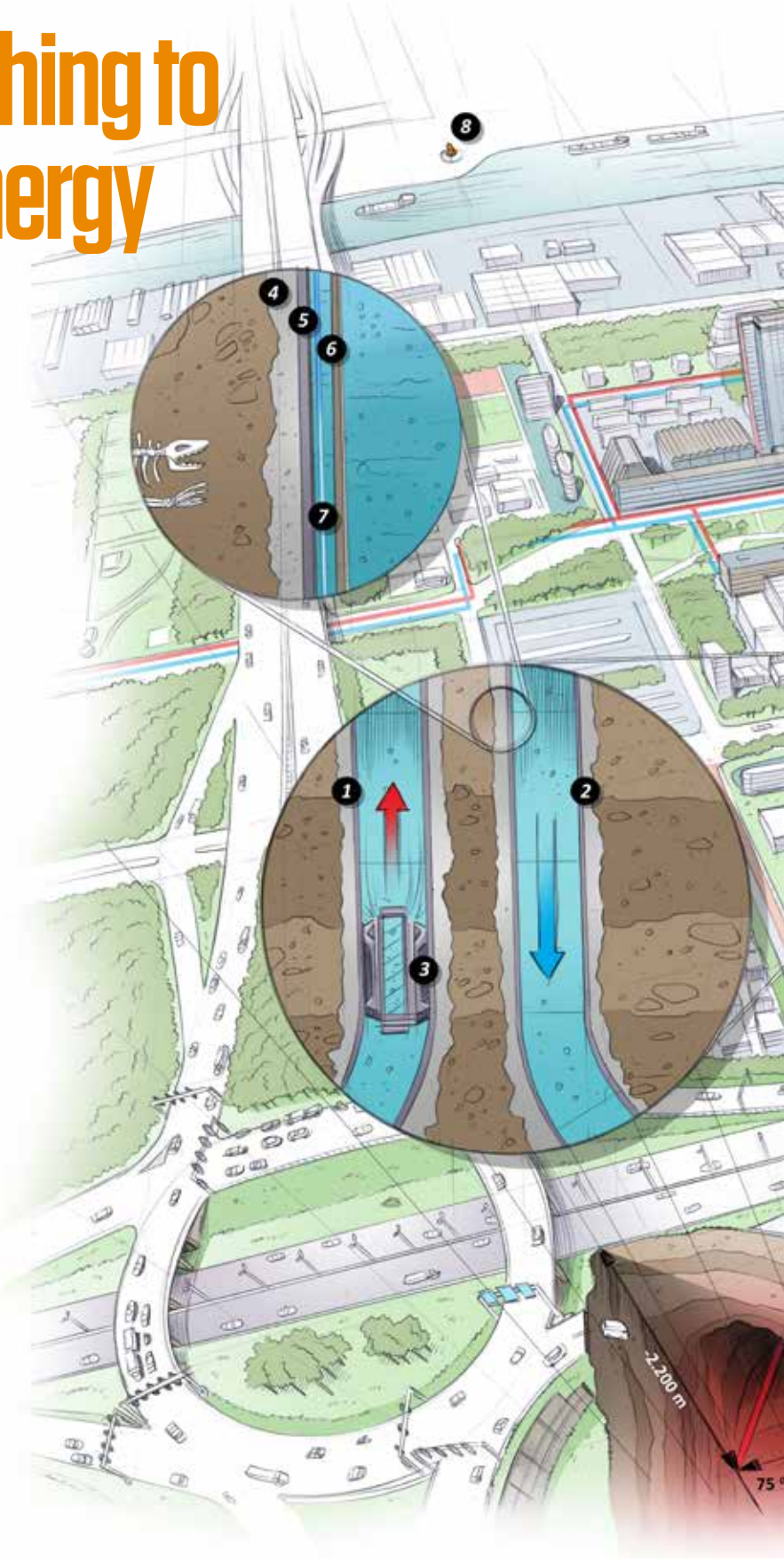
TEXT: JOS WASSINK ILLUSTRATION: STEPHAN TIMMERS

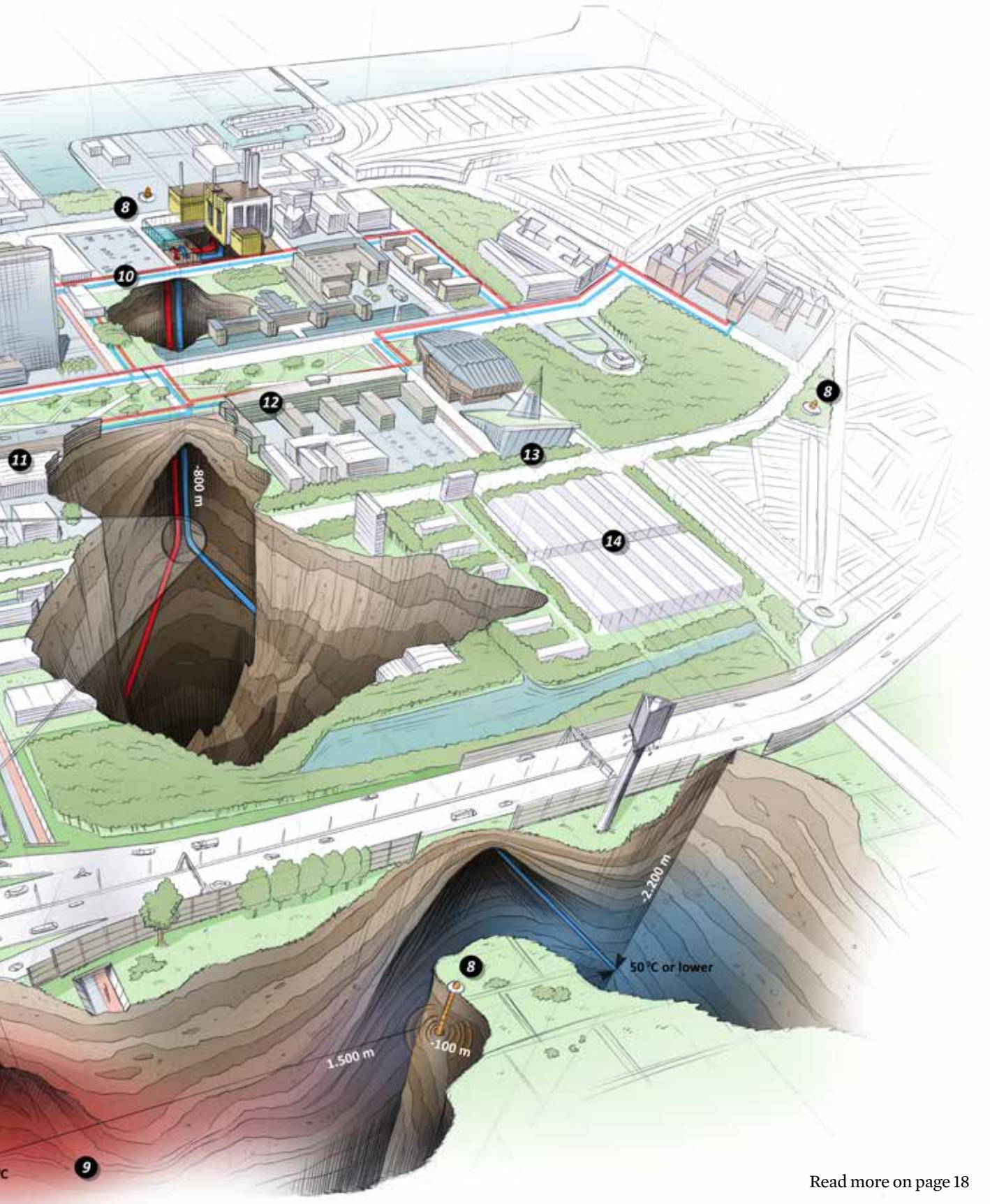
Campus switching to geothermal energy

At the end of 2020, two pipelines will be bored from the campus to a hot-water reservoir, more than 2 kilometres below the A13 motorway. This geothermal energy source, at 75 degrees, will be used to heat buildings on campus and in the surrounding area.

The installation consists of an (1) intake pipe and a (2) discharge pipe that will drop 800 metres vertically from Leeghwaterstraat. At around 500 metres deep, a (3) pump will pump 300 cubic metres of water per hour – enough to fill twelve lorries. From a bend at 800 metres deep, the pipelines run off to different parts of the same hot water source located at a depth of 2.3 kilometres. At the surface the intake (producer) has a temperature of about 75 degrees. The discharge (injector) has a temperature of 50 degrees. As the groundwater flows from the injector to the producer, it heats up again due to the geothermal heat.

The pipes have a diameter of 50cm at the surface; at the bottom of the well this is 10 to 15cm. In order to prevent leaks due to corrosion from the hot and salty groundwater, the pipes are multi-layered, with a cement outer wall (4), followed by a steel pipe (5) and an epoxy inner lining (6). There is a (7) fibre-optic cable in the water flow for measuring the temperature and pressure inside the pipe. Seismometers (8) are installed at four locations around the well at a depth of around 100 metres, which is deep enough to isolate them from surface activity. The measuring points register the structure of the subsurface via high-resolution seismic measurements. They also use electromagnetic measurements to >>





Read more on page 18

detect differences in density, and thus the groundwater flow through the (9) reservoir.
An installation to capture natural gas from the groundwater will be built on Leeghwaterstraat, next to the existing cogeneration plant. The hot groundwater will then be filtered and passed through a heat exchanger that will transfer the heat from the groundwater to the campus' (10) heat grid at a temperature of 75 degrees. In older buildings (11, 12), changes will have to be made to the heating systems since they are set to a higher input temperature. These changes were already planned but have now been brought forward. After passing through the heat exchanger the temperature of the water is about 50 degrees.

CLIMATE-NEUTRAL HEATING

It will cost around € 22 million to construct the doublet (combined intake and discharge of hot groundwater), plus an additional € 8 million for research. The well is expected to provide climate-neutral heating for the campus and its surroundings for about 30 years. With a return temperature of 50 degrees, the well will provide more than 8 megawatts of thermal power.
The Netherlands currently has more than 20 doublets (there are two near Delft, in Duijvestein and Ammerlaan), most of which were installed on the initiative of market gardeners. The Dutch Platform Geothermie wants to triple that number to 75 by 2025. In the longer term, Energie Bedrijf Nederland (EBN) is aiming for as many as 700 doublets by 2050.
Dr Phil Vardon (CEG) is coordinating the geothermal project, known as the Delft Geothermal Heat Project (Delfts Aardwarmte Project, DAP) when it was launched in 2008. According to Vardon, this project is particularly exciting because it combines heat production with research. And it brings together various fields: geology, geophysics, data-assimilation, reservoir simulations and geochemistry.
With four measuring wells and two fibre-optic cables in the pipelines, this will be the best-monitored doublet ever. The shape and dimensions of the reservoir, the flow of water at different temperatures, any cracks appearing in the rock – everything will be measured. Vardon is hoping for plenty of data so that researchers in practice, with far fewer measuring systems, can still get enough information about the well. Continuously feeding computer simulations with new measurement data reduces uncertainties in the calculations. This method, data assimilation, is also applied to weather models.

LITTLE IS KNOWN

For another programme, researchers will also be collecting a lot of core samples – especially from the layer between 100 metres and 2 kilometres deep, about which little is known. This layer never attracted much interest since it contains no oil or gas. Researchers now want to know whether this interlayer offers possibilities for deep geothermal heat storage (aquifer thermal energy storage or ATES).
What should we do with geothermal energy when the heating is off? In the summer, there is less demand for geothermal energy but the pump continues to run – albeit at a lower rate. What can we do with 75-degree water when it's 30 degrees outside? Vardon mentions three applications that are currently being explored. One option is to use it to heat up shallow geothermal systems, such as those used at the library (13). Another is to convert it into electricity using an organic rankine cycle (an organic liquid with a low boiling point is used to power a steam turbine). And then there's the paradox of using geothermal energy for cooling.

COLLABORATION

TU Delft is a partner in the Delft geothermal project, together with EBN and the company Hydreco Geomec. Once the final negotiations have been completed, the partners will set up a company that will manage the installation and the production of geothermal heat for the campus.
In July, TU Delft also signed a collaboration agreement with housing corporations Woonbron, Vestia, Videomes, DUWO, NetVerder and the City of Delft to construct a heat grid that will allow surplus geothermal energy to flow into the neighbourhoods (14) at 50 degrees. The return temperature then drops to 30 degrees, increasing the supplied power from 8 to 15 megawatts. <<

Carbonated water for steam and power

Delft geophysicists are participating in the international Succeed study into the effects of CO_2 storage in geothermal geysers. How does the gas affect the subsurface?

"In the Netherlands you can pump hot water out of the ground, but in Iceland, Turkey and New Zealand there is steam everywhere," says Dr Karl-Heinz Wolf. "Geysers erupt continuously, fed by an almost endless supply of geothermal energy and by water that flows down through large fault zones." This releases so much steam that connected generators produce as much electricity as a large coal-fired power station.

A geothermal well seems like an eternal source of green electricity. But it often doesn't last that long. Steam pressure can drop over time (at least 40 bar of working pressure is required to power a turbine) because the water supply decreases, or because passages become blocked due to an earthquake.

And nor is geothermal steam climate neutral. Along with water and steam, greenhouse gases such as CO_2 and CH_4 (methane) are released from the ground. Depending on the composition of the ground, carbon emissions can be close to half of that produced by a gas-fired power station.

SUCCEED

How great would it be if you could capture the CO_2 and inject it back into the ground with the cold water so that it also stimulates production? The Succeed research project (Synergetic Utilisation of CO_2 Storage Captured with gEothermal Energy Deployment) is attempting to do precisely that.

PHOTO'S: KARL-HEINZ WOLF

The Wairakei energy station in New-Zealand.

One cubic metre of water in the subsurface can contain about 10% CO_2 by volume, Wolf estimates. This carbonated water is injected under high pressure and dissolves in water at a depth of a few kilometres, at fluid pressures above 100 bar. According to the researchers, carbon dioxide gas in the return flow can have a dual effect. Under the influence of the acidic spring water, mineralogical changes take place in porous rock underground. For example, the micropores in limestone can become worm-like pores, which increases their permeability. During the ascent the carbon dioxide dissolved in hot water will create additional expansion – and a greater steam pressure.

FIELD MEASUREMENTS

To test these expectations, researchers want to be able to follow the CO_2 water mix in the subsurface. This requires field measurements and geo-physical laboratory research. The Applied Geophysics and Petrophysics research group (CEG) is to participate in field experiments in Turkey as a research partner, producing images of the subsurface and providing lab support.

Delft researchers are working alongside the company Seismic Mechatronics to take and interpret seismic measurements. An environmentally friendly electric vibration source, developed by Dr. Guy Drijkoningen (CEG), transmits signals through the subsurface, while a network of fibre-optic cables in the well and at the surface registers the return signals from the subsurface.

In four years' time, we should be able to understand the effect of injecting CO_2 into the geothermal source. JW

Going underground

In the over seven kilometres of tunnels beneath the TU Delft campus you will find heating pipes, cables and – once a year – an inspector. Delft Outlook was invited to join him.

An underground expedition. We liked the sound of that. To access the mysterious tunnel system, we turn to Anne Medema, Energy Team project manager at TU Delfts' Combined Heat and Power Plant.

Before going deep underground, Medema shows us around the power station; the start of our journey.

The massive building, built in 1952, houses three large boilers and two cogeneration units that provide heat and power. The boilers generate about 50,000 MWh of thermal heat per year, which is pumped through many pipes to all the buildings on the campus.

"Those pipes run through the heat shaft, or tunnels as you call them," says Medema.

This heat shaft is already 65 years old but is still in good condition. "The heat grid has changed a lot," says Medema. "First coal, then fuel oil and finally gas-fired boilers." The campus' heat grid is currently being made suitable for more sustainable sources, so that heat can be transferred to the buildings at lower temperatures.

After our tour of the plant, management technician Benno Bajema takes us on an expedition. He inspects the tunnels every year. Slightly apprehensive, we look on as Bajema removes the manhole cover. Glancing over the edge we can see scarily steep steps ending in a puddle of murky water. After the valuable advice to 'be careful', we lower ourselves somewhat awkwardly into the 5m-deep manhole. Medema stays above ground, "to make sure no one slides the cover back," he winked.

Armed with a torch, we carefully shuffle along behind each other. Every few metres, Bajema points out the things he checks. "Is the emergency lighting working, are the pipes still intact, that sort of thing."

With autumn approaching we notice that the tunnel is pleasantly warm. "My predecessor told me that homeless people used to sleep here because it was warm," says Bajema. "But since the manhole covers have been fitted with alarms, they can't do that anymore."

Fortunately, except for a few spiders, we don't encounter any other residents during our expedition. After more than half an hour in the dark our trip comes to an end and we climb up the iron steps. While our eyes get used to the daylight, Medema and Bajema put the manhole cover back in place. "Is everyone here?" MvdV

The boilers generate about 50,000 MWh of thermal heat per year, which is pumped through many pipes to all the buildings on the campus

Benno Bajema inspects the tunnels every year.

View

Professor of environmental geotechnology Timo Heimovaara (CEG) is studying ways to extract raw materials without producing waste and emissions.

"I'm studying the impact of human activity on the subsurface and how we can reduce it. When I joined TU Delft in 2007, one of the first initiatives was the STW perspective programme BioGeoCivil, in which we studied the use of natural processes as a building material. One of my colleagues, Leon van Paassen, is researching the use of microorganisms to cement sand into sandstone.

The subsurface is a living ecosystem that can provide us with many services. My dream is that we will appreciate these services and use them more sustainably so that future generations can also continue to benefit.

At Geoscience and Engineering it is our mission to discover and study underground resources and to support their use in an environmentally friendly way. That's what it says on the wall. We provide support for the use of the subsoil and the extraction of raw materials. We do this in an environmentally friendly way, which means no waste, no emissions and a minimal impact, while striving for circularity.

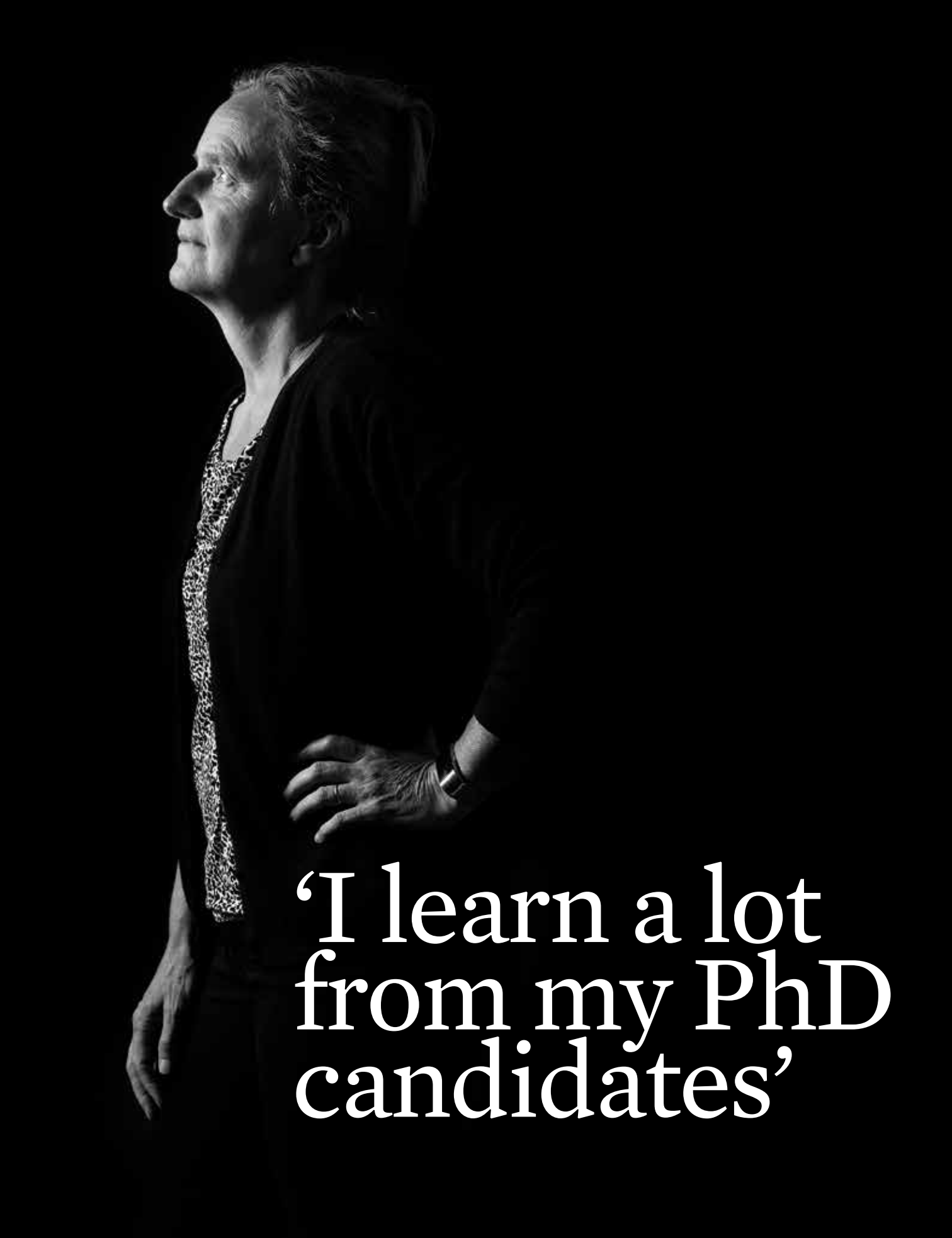
At present, the Netherlands still obtains 90% of its energy from fossil fuels. We can't just stop using them overnight. We need to guide the fossil industry towards waste-free and emission-free extraction methods. Our students demand the same of us. They will have to go implement the energy transition.

The first approach is to say to the business community: we want to do research with you – we are also dependent on external funding – but we want to do this in such a way that we can meet the long-term objective of zero waste, zero emissions and a minimal impact.

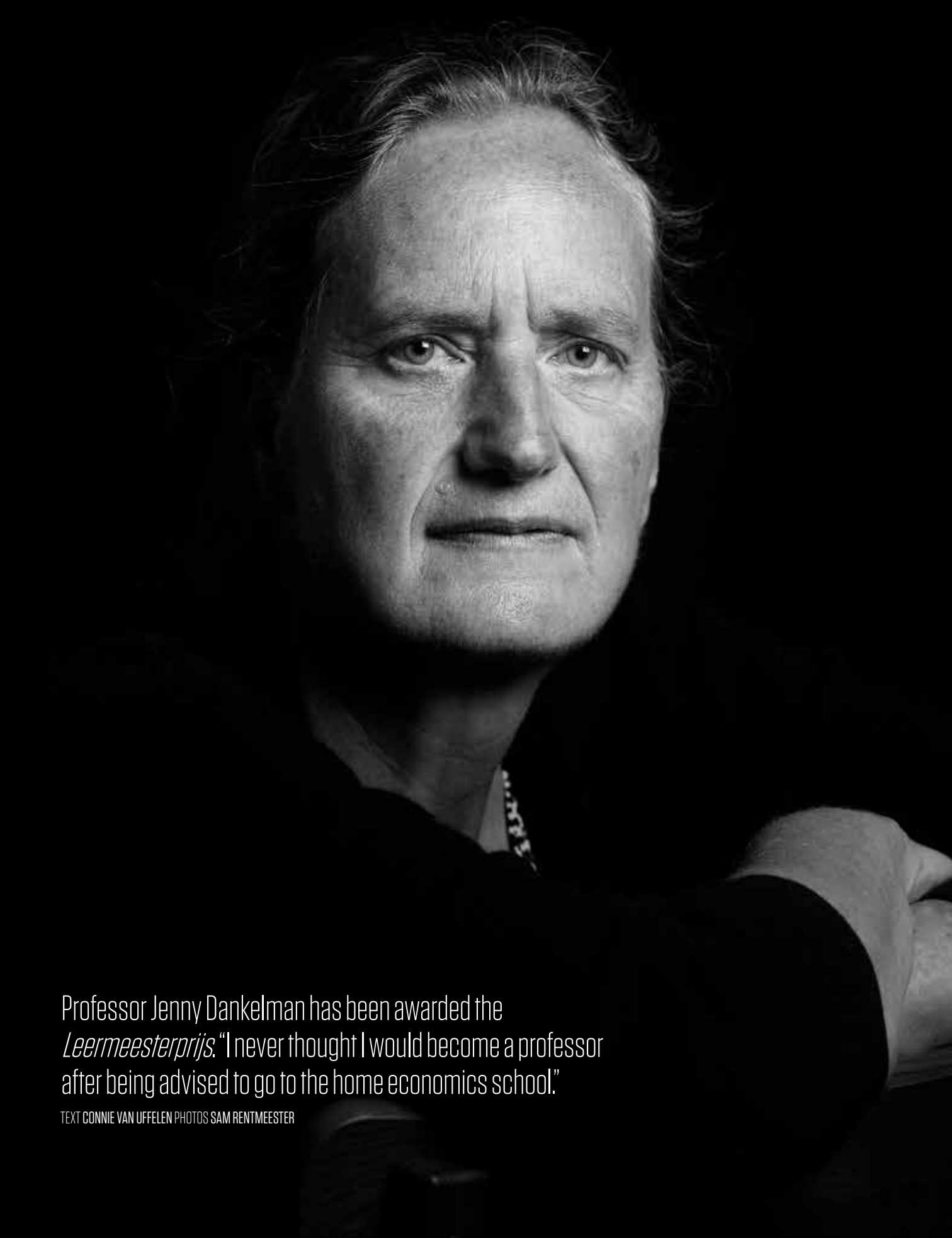
This is particularly difficult for mining. Preventing emissions and waste isn't cheap. As consumers, we must be willing to pay for this, but we don't want to. Nevertheless, I think that we at TU Delft should have the courage to lead the way, for example, by advising on how to achieve a minimum impact. There are methods where the waste is kept below ground and the ore is dissolved using acid and purified above ground. But this method of extraction will only be feasible if we tax the current mining industry on all the associated effects. You can achieve a lot for the right price. But I'm an optimist.

Sustainable land use also has an impact. There are plans to increase geothermal energy production 100-fold by 2050. That means drilling holes all over the Netherlands, but that makes underground hydrogen storage impossible, even though this could be much more beneficial than having hot water.

As a university, we build on the knowledge we have gained for the oil and gas industry, but we can also use that knowledge and experience for completely different subsurface applications such as gas storage and geothermal energy. We want to harness the potential of the subsurface to benefit society." JW



‘I learn a lot from my PhD candidates’



Professor Jenny Dankelman has been awarded the *Leermeesterprijs*. "I never thought I would become a professor after being advised to go to the home economics school."

TEXT CONNIE VAN UFFELEN PHOTOS SAM RENTMEESTER

A professor that stands out in teaching and research is nominated by students and PhD candidates. Only a professor like that qualifies for the Professor of Exellence Award (a best professor award from the Universiteitsfonds Delft). Jenny Dankelman is awarded this accolade for her research into innovative medical instruments and her ability to teach.

What does the Professor of Excellence Award mean to you?

"It is a very meaningful award because I have been nominated by people with whom I work closely and that I try to help do their work as well as they can. Their token of appreciation is very humbling. It's very special."

What do you think you do to have won this award from your colleagues and PhD candidates?

"I think it's mostly because I really enjoy teaching graduates and PhD candidates. I like helping them get the best out of themselves. And I also try to understand any problems that arise. My door is almost always open for them to just come in."

Who do you see as your teacher?

"The most important were my predecessors and promoters who taught me and from whom I learned a lot. They are Henk Stassen, Jos Spaan of the AMC and Kees Grimbergen."

What do you value about them?

"Henk Stassen taught me a lot about working closely with clinicians. He taught me that you need to observe them in the operating rooms as well and that you need to know exactly what they do there and why. He believed much more in my abilities than I did myself. I never thought that I would become a professor after the advice to go to the home economics school. Jos Spaan taught me how to set up research well. How to look critically at your data and how to write scientific articles. Kees Grimbergen introduced me to minimally invasive techniques."

You graduated in mathematics. How did you end up in the medical world?

She laughs. "I never even dreamt that I would end up in the medical world, let alone learn surgery. It was a bit of a coincidence. While I was working on my graduation project, I was alerted to a PhD position in technical mathematics at TU Delft. I applied and thought that it would be useful to practice a job interview. I had never done one before. I took the first vacancy that appeared. It was research into the circulation of the heart muscle at Mechanical Engineering. It was an informal meeting and I was completely relaxed. Jos Spaan and Henk Stassen, the promoters, were keen and said immediately that the position was mine if I wanted it. I asked for two weeks to think about it. They subsequently sent me all sorts of articles that I could not even read because I did not know any medical terminology. In the end, I liked it so much that I decided to do it. I have never regretted it."

Was it hard to connect the technical and the medical worlds?

"No, it was not hard; it just took a lot of time. You need to enter into each other's fields, know the issues at play and learn the professional terms. You can help each other move forward as the medical field has a lot more technical resources

'I never dreamt that I would end up in the medical world'

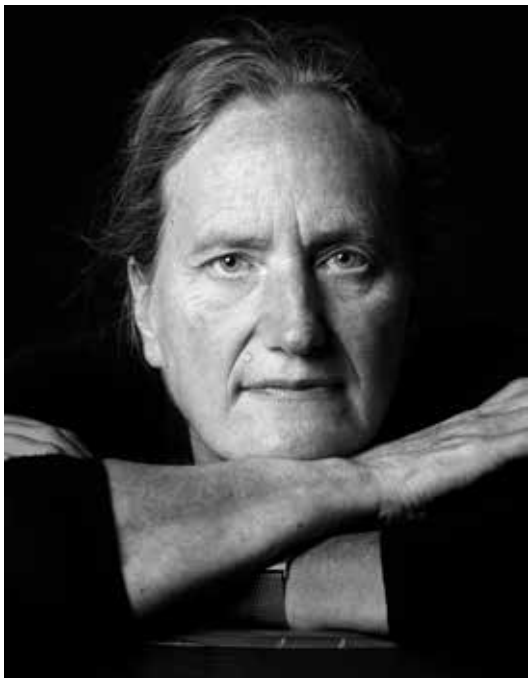
available which clinicians need to learn to work with. Their need is more for new technical solutions. Minimally invasive surgical techniques entered the field at the beginning of the 1990s. From then onwards, these techniques are being used a lot more in operation rooms. Before that, it was not done much – surgeons could do a lot with needles and scalpels. Now the emphasis is to minimise damage to healthy human tissue."

You are heavily involved in developing new curricula for master programmes. What do you want to pass on to your master students?

"Enough medical knowledge about anatomy and physiology. It is important to communicate well with medical people and to know their fields of expertise. This calls for time and energy. There are so many connections in this world. If there is something wrong with our bodies, we try to replace, support or cure something. You need technology to do this. We are trying to do more and more through small incisions with minimally invasive surgical techniques. Over the last five years or so, I have tried to encourage students and PhD candidates to do something for low-income countries. Do you know my story?"

CV

Prof. Jenny Dankelman (1961) studied mathematics at the University of Groningen. She obtained her doctorate at the Man-Machine Systems Group at TU Delft and in 2001 became Professor of Minimally Invasive Surgical Techniques. In 2018 she became Knight in the Order of the Lion of the Netherlands for her work on developing medical instruments that minimise damage to healthy tissue, and because of her work in connecting the technical and medical worlds. She is a member of the Royal Netherlands Academy of Arts and Sciences.



No, tell us your story.
"Five years ago someone put a few pages from the Linda magazine in my pigeon hole. I still don't know who it was."

Dankelman gets up and fetches the article. "It was about women in Africa who were ostracised because they smelled. They smelled because they had been horribly raped and did not have access to surgery and were not treated. The article sat on my desk for weeks. I started to read more about it and found out that there are three million women with similar problems caused by protracted childbirths. The tissue in your uterus and stomach gets torn. I discovered that two billion people do not have access to surgery and five billion do not have access to safe surgery."

Unimaginable ...
"Yes. I felt that I had to do something. I submitted a project proposal to the Open Mind project at the Technologiestichting STW, but ended up fifth. At the time, Delft Global had just been founded. I submitted an application and could start with one PhD candidate. She had been to the African continent and was familiar with different cultures. She taught me – as you see, I learn from my PhD candidates – that it is important to know the context. You need to know what happens where. Another researcher that obtained his doctorate with me, told me that, after working in industry for four years, that he wanted to move to Nepal with his family. He asked me if I knew of anything he could do there. I had an idea and that was to see how we could improve the training of biomedical engineers and support medical technology departments in hospitals. Last year eight students went to Nepal, five to Kenya and three to Surinam. They are all working on hospital equipment."

You put your efforts into women as you were one of the founders of the Dewis, Delft Women in Science women's network. What was the trigger for you to do this?
"When I was first asked, I thought that I should refuse. I thought that it wouldn't be my thing. I was used to being in a 'man's world'.

Were you afraid of being seen as 'a complainer'?
"Yes. But when I was asked again, I thought why not? I have learned a lot from this experience, such as that it is important to know the differences in men's and women's behaviour. In December 1984 I was the Faculty's first female PhD candidate. With hindsight I can see that I never was seen as 'one of them'. You do your best to not stand out and to be one of them, but that gets very tiring after a while."

What was so tiring?
"Letters that start with 'Dear Sir'. Researchers are often anonymous and people thought that I was the secretary. Not that that's bad of course, but if it's not you, you don't really feel comfortable. In the end I learned to recognise and understand the behaviour of men better. If you lead a group for example, and are facing a choice between A and B and you say 'what shall we do, A or B?', you are seen as not knowing the direction you need to go in. A man just says 'shall we go for A?' and if everyone says B, goes all out for B. It's good to give people a choice, but it's a more female approach. I learned to remain true to myself."

You make a modest and somewhat shy impression. At the same time, you are hugely respected in the technical and medical worlds. What is your secret?
"To do my best. It is important to respect diversity. We need to be careful if we put our technical hats on and think that we can do things better. Technical innovation takes time. You need patience. I enjoy it and that's maybe the most important thing." <<

TEXT: AMANDA VERDONK PHOTO: SAM RENTMEESTER

Lucky find becomes **top material**

The Kaumera extraction plant under construction.

Researchers at Delft have discovered a versatile raw material that is created during the 'Nereda' wastewater treatment process. The first factory for recovering this dry or gum-like substance, called Kaumera, recently opened in Zutphen. Its potential uses range from seed coating to composite materials.

We visited the modest production hall in the Zutphen factory, next to the wastewater treatment plant, where fitters, welders and technicians were busy putting the finishing touches to the world's first Kaumera extraction plant. This collection of processing plants, including a belt thickener, heat exchanger, reactor, centrifuges and storage silo will soon be producing a brand-new raw material.

"This is the first time we are extracting a totally new material from wastewater', says Sandra de Wit, policy advisor at the Rijn en IJssel Water Authority, who is convinced of its great potential. The material was discovered purely by chance a few years ago by TU Delft researchers. They decided to call it Kaumera, which means chameleon in Maori, the language of the indigenous people of New Zealand. De Wit: "Just like a chameleon, this material can adapt to its surroundings, which makes it very versatile."

One customer has already been found: the Amsterdam biotech company Chaincraft. Potential uses for Kaumera include seed coatings in the agricultural sector, concrete coating in the construction sector and composite materials for the automotive industry. Around a third of all waste sludge can be put to good use for Kaumera production, rather than ending up in a waste incinerator or processor.

By-product of Nereda

Kaumera is not formed during every wastewater treatment process, it is a by-product of a new wastewater treatment technology called Nereda.

3000 ton

Amount of wet material to be produced annually in the factory, dry material is 10% of this volume. There is scope to double the capacity

Proportion of waste sludge containing Kaumera

1/3

Investment costs, funded by the Rijn en IJssel Water Authority and the European Union

€13,6 million

Number of Nereda wastewater plants in operation worldwide

70

Number of partners involved in the Kaumera factory: Rijn en IJssel and Vallei en Veluwe Water Authorities, TU Delft, RoyalHaskoningDHV, Chaincraft, Stowa, Energy and Resources Factory, Koploperwaterschappen and the EU Life Programme

9

This technology was also originally developed by TU Delft researchers, who discovered a special bacterial treatment for waste sludge that causes it to settle in granules rather than flakes. This accelerates the settling process so fewer storage tanks are needed and the entire plant takes up less space. The technology has been further developed in recent years by RoyalHaskoningDHV and is now in use at seventy locations worldwide.

Brainchild

The Nereda technology is the brainchild of Mark van Loosdrecht, Professor of Environmental Biotechnology and winner of the Spinoza Prize. He came across the PhD research of Yuemei Lin from China, who discovered an alginate-like substance in sludge granules. Alginate is used as a raw material for bioplastic, that is usually produced from seaweed. "The substance resembles alginate, but has a completely different composition", says Van Loosdrecht. "It has high rigidity, is very strong and non-combustible, a unique combination of properties that makes it suitable for high performance materials, such as fire doors, ship coatings and materials in the aeronautical and automotive industries."

The material can also be produced on a larger scale than alginate from seaweed, making it considerably cheaper. "If all the existing Nereda plants were to produce Kaumera, this would already equal the current volume of the total alginate market", says Van Loosdrecht. The collaboration with Chaincraft, which will be purchasing the total production for the first two years, is expected to eventually lead to a cost-effective investment.

> Not only factory wastewater, but also our own faeces and urine will be given a new and useful lease of life

The plant in Zutphen takes its wastewater from a single source: the FrieslandCampina dairy plant in Lochem. A sewer pipe that formerly transported the wastewater to the adjacent treatment plant, has been diverted to feed directly into one of the new Nereda tanks where the granulate is produced that is then fed through the new extraction plant to produce Kaumera.

In early 2020, another Kaumera plant will start operating in Epe that will also process domestic wastewater; so not only factory wastewater, but also our own faeces and urine will be given a new and useful lease of life. Van Loosdrecht: "It's really great that with a little creativity we can create high-performance materials from something that you flush down the toilet."

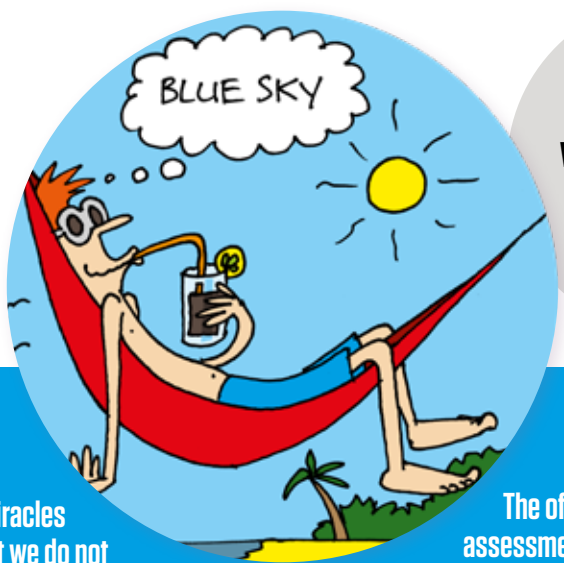
Does the discovery of Kaumera equal that of graphene, the two-dimensional carbon material that earned the Dutch-British physicist Andre Geim the Nobel Prize in Physics? Van Loosdrecht hesitates. "I would rather let others be the judge of that. But a comparison may be made with the playful aspect of the discovery of graphene, where Friday afternoons were spent working on crazy ideas." He feels that this discovery shows that even research that doesn't have a previously defined goal can be useful. "When we started this work it not a fashionable subject. We just wanted to know more about the bacteria involved; we had no idea we could use it to create a material. That was pure serendipity." <<

HORA EST

To help easier integration of minorities, the Dutch language should drop the different articles and use only the 'de' article

Dr. Alaaeddin Ayyoub Swidan, ICT engineer

"I've been learning Dutch for four years now, but I still find it difficult to speak in public. One of the reasons is that I keep making mistakes between 'de' and 'het', the related possessions 'onze' and 'ons', and the adjectives 'mooi' and 'mooie'. I want to be perfect, but I cannot memorise the prepositions for all these words. There is no logic! And it erodes my confidence. Dutch people immediately hear mistakes in 'de' and 'het'. They think it's annoying, and even if they don't show it to your face, they label you as non-Dutch. My daughter is now in primary school and, perhaps because she is drawn to other children from minorities, she doesn't really focus on prepositions. I think the Dutch language will evolve dynamically to lose the 'het' word. But even if it doesn't, can we agree that such mistakes are not important and move on to discuss more interesting things?"



Blue-sky thinking will lead to failure for most PhD students.
Zhaoling Li

Supernatural phenomena and miracles are natural phenomena that we do not understand yet!
Hamed Ahmadpanani

The often individual-focused assessment mechanism in academia is harmful for collaboration.
Danique Ton

Taking a course is a more efficient way to learn a programming language than practice.
Yaqing Shu

Aqueous batteries will replace stationary Li-ion batteries.
Zhaoling Li

To the perceptual system of a robot, reality is nothing more than a very complex simulation.
Kirk Yannick Willehm Scheper

A decent researcher is someone who can think quickly and boldly, but speak/write slowly and carefully.
Qingli Li

After Delft

Joris Thijssen's fascination with space travel began when, as a child, he heard that Wubbo Ockels was going to be an astronaut. His studies however, do not take him to space but to Greenpeace.

Photo: Sam Rentmeester

How amazing is that? As a child Wubbo Ockels inspired you to become an astronaut and years later you hear that the same Ockels is to be a professor at your TU Delft. Joris Thijssen wasted no time and asked Ockels what he needed to do to be supervised by him for his graduation project. He was told that he first needed to be a bit further along in his studies – he'd only just finished his first year.

Thijssen thought there was more to life than studying and after his second year he went travelling for a year. It got him thinking about what mankind is 'doing' to the earth and he decided to volunteer for Greenpeace alongside his studies. Thijssen's inner environmental activist was born.

In 2000, under Ockels supervision (of course!), he graduated with a project examining the design of the Lunar Lander that would go to the South Pole of the moon with the Ariane 4 rocket. He investigated whether this could also be an Ariane 5 mission with extra satellites and how the rocket could fly to the moon from an orbit around the Earth.

Thijssen then went to Russia with Greenpeace for six weeks to attract public attention to Shell's oil spills. With another TU alumnus, Diederik Samsom (now a politician in the Dutch Labour Party), he carried out measurements in France to detect radioactive discharge.

Back in the Netherlands, he worked for Greenpeace as a typist. The 'old hands' showed him the ropes of campaigning. His degree proved to be useful. "We analyse the environmental problem, look for a solution and take action based on that," he says. Within a year he was appointed campaign manager, first for nuclear energy and then for climate change.

Nevertheless, Thijssen deliberated for a long time whether he should do something with his engineering degree. In 2003 he applied for a job at Astrium in England, the civil aerospace division of the European defence company, EADS, where he had done an internship. A day before he was about to start, he was called to say his position had been dropped due to budget cuts.

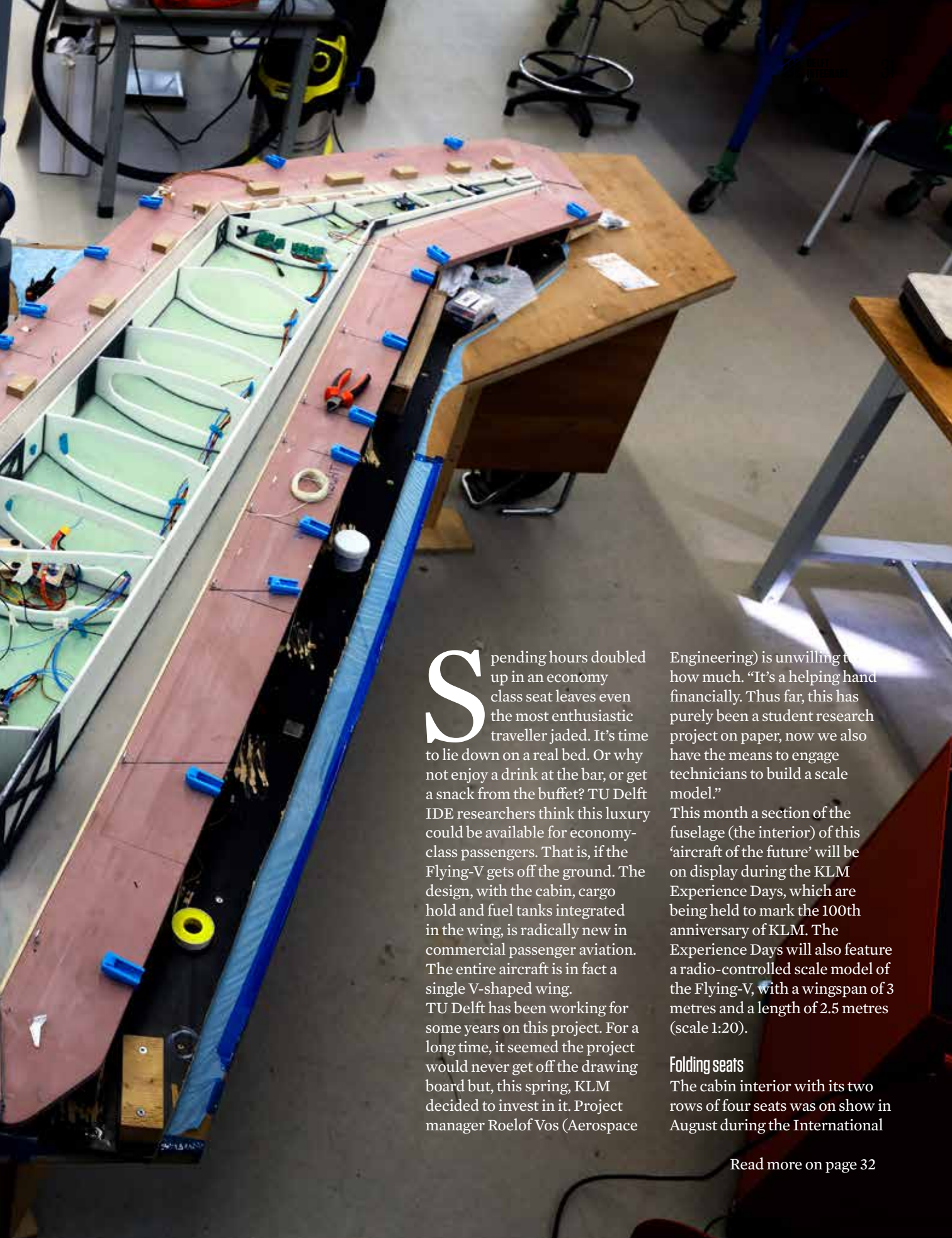
Greenpeace welcomed him back as a campaign manager. In 2007 he helped the office in China and then went on to work with 20 offices all over the world at Greenpeace International, until he became a father and wanted to travel less. The 'mystery of management', as he calls it, beckoned. He became campaign director and in 2016 was appointed director of Greenpeace Nederland.

> His degree proved to be useful for campaigning

Straight after, he and others connected a 500m line between two wind turbines in Eemshaven and hung there strapped in climbing harnesses, for 24 hours to stop a coal ship from passing. "My coolest protest." GVL

Will the Flying-V get off the ground?

Reseachers at the faculties of AE and IDE are working on a new type of aircraft; the Flying-V. This tailless plane integrates the cabin, cargo hold and fuel tanks in the wing. Just how feasible is the design?



Spending hours doubled up in an economy class seat leaves even the most enthusiastic traveller jaded. It's time to lie down on a real bed. Or why not enjoy a drink at the bar, or get a snack from the buffet? TU Delft IDE researchers think this luxury could be available for economy-class passengers. That is, if the Flying-V gets off the ground. The design, with the cabin, cargo hold and fuel tanks integrated in the wing, is radically new in commercial passenger aviation. The entire aircraft is in fact a single V-shaped wing.

TU Delft has been working for some years on this project. For a long time, it seemed the project would never get off the drawing board but, this spring, KLM decided to invest in it. Project manager Roelof Vos (Aerospace Engineering) is unwilling to say how much. "It's a helping hand financially. Thus far, this has purely been a student research project on paper, now we also have the means to engage technicians to build a scale model."

This month a section of the fuselage (the interior) of this 'aircraft of the future' will be on display during the KLM Experience Days, which are being held to mark the 100th anniversary of KLM. The Experience Days will also feature a radio-controlled scale model of the Flying-V, with a wingspan of 3 metres and a length of 2.5 metres (scale 1:20).

Folding seats

The cabin interior with its two rows of four seats was on show in August during the International

Read more on page 32

Comfort Congress in the faculty building of Industrial Design Engineering. Thomas Rotte, a member of the Flying-V project team, explains some of the innovations in the cabin: "The seats are not in straight rows like a traditional aircraft, but are staggered to create extra leg and shoulder room. As the aircraft is V-shaped and the longitudinal direction of the fuselage is not the direction of flight, the staggering of the seats creates no extra wasted space. And coincidentally it allows us to put the seats precisely in the direction of flight."
Another nice detail: the seats can be folded. "This makes the boarding process much easier. It is easier to get in and out of the row, even with hand baggage, reducing congestion in the aisle. Another advantage is that children can sit more comfortably on the folded up seat, and it allows adults to change position should they wish to stretch their legs."
It took the congress visitors some time to get used to the design. "OK, it is more spacious. But there's also less privacy", said a lady in the second row. "The staggered seats mean I'm sitting diagonally across from my neighbour and can easily see his tablet screen." Her neighbour in turn was surprised that the seats are not parallel to the walls of the fuselage. "Won't this mean we all get airsick? We're not sitting in the direction of flight." But of course they are sitting in this direction, due to the aircraft's V shape.


It took the congress visitors some time to get used to the design.

Privacy

PhD candidate Meng Li, of the Applied Ergonomics and Design research group, has thought of a solution to the privacy problem. See sees the passengers of the future being able to screen themselves off from other passengers using a hood on the armrest that you can pull out to shoulder height and which contains a TV screen so you can watch films undisturbed during the flight. The hood itself is transparent, but can be darkened using a simple sliding mechanism. In addition to the extra comfort provided by the extra leg room and gadgets, the aircraft is fitted with beds. Project team member Rotte says there is room between the ribs, which reinforce the hull, for bunk beds on the inner side of the aircraft (towards the point of the V).
The beds were not ready in time for the congress. "It proved really tricky to create bunk beds that you can also transform into seats", Rotte explains. "And that's a vital requirement as all passengers need to be seated with seatbelts on for take-off and landing. We have come up with a system for this, which we will be patenting, but until the patents are granted we won't be showing the system."
The aircraft will also have some areas where you can sit with four people facing each other, like in trains. And there will be lounge chairs that fully recline. These seats are also placed in a staggered formation to save space, but then vertically. This means that when reclined, the legs of the rear passenger are half under the seat in front.
The question remains of how the cabin crew can bring round the meals and drinks. With four seats in a row, it is no longer possible to reach across to the furthest passenger in the window seat, let alone if the rows are even longer. Rotte thinks the meal and drinks service may need to be revised. "The seating configuration where the two wings converge is problematic as you get passenger flows from both wings. So it's not very handy to put seats there, but it might be just the place to put a buffet."

> 'Our aircraft can be easily lengthened or shortened. This is needed for a new type of aircraft to be profitable. This was not possible in blended-wing designs until now'

Blended wing concept

Back in time. Since the 1950s, designers have been working to improve jet aircraft with their distinctive cigar-shaped fuselage. Since they conquered the skies, they have become more energy-efficient and quieter, but the limits have now been reached. To gain even more

efficiency, aircraft manufacturers need to switch to a radical new design. Aircraft where the wings and fuselage are integrated in a blended-wing body are far more aerodynamic. The military has been using this design since as far back as the 1940s; an example is the American Northrop YB-49, which first took to the skies in 1947. The Flying-V closely resembles this design, except for its cargo: the Northrop carried bombs, not passengers. Commercial passenger aviation has so far resisted the blended wing. The Delft researchers hope to change this.

AE project leader Roelof Vos explains that this design differs from the old blended-wing concept on a crucial point. "Our aircraft can be easily lengthened or shortened. This is needed for a new type of aircraft to be profitable. This was not possible in blended-wing designs until now."

The TU Delft engineers are building on a patent from Airbus. In 2014, a student at TU Berlin, who was doing a traineeship at Airbus, stuck two A320 fuselages together in a V-shaped wing on the drawing board and made the whole thing more streamlined. He added an extra two small wings to the tips. Airbus saw the potential and patented the design.

Vos was intrigued. "With a healthily critical academic attitude, we started an independent study. We made calculations and adjusted the shape." The more aerodynamic shape and lower weight of this aircraft means it should use twenty percent less fuel than the Airbus A350, which serves as a reference. The Flying-V should be able to carry the same number of passengers (314) as the A350 and the same volume of cargo (160m3).

The Flying-V is shorter than the A350, but has the same wingspan. This means it should have no problems using the existing infrastructure at airports, such as gates and taxiways, and it fits in the same hangar as the A350. However, even if the project continues, it will be a long time before a plane like this actually carries passengers. "Passengers will have to wait until 2040 at the earliest", says Vos.

Assembly model

Just before this magazine went to press, work was continuing on the radio-controlled model of the plane. Researcher Malcom Brown (AE) showed us around the workshop where he is assembling the plane step-by-step, using a robot arm that knows the precise position of every part.

"Soon we will be gluing the top and bottom of the fuselage together, then we won't be able to get to anything, so all the electronics need to work perfectly."

Brown sees stability as an enormous challenge for the plane. "In a traditional aircraft, the rudder is right at the back, in the tail. Our model has to be steered by the wings. That's a lot more tricky."

Will the plane have flown before it is displayed at Schiphol? Brown can't say for sure. "It certainly won't be flying when it's on show at Schiphol. That would be too dangerous."

G forces

The technology website arstechnica.com has been critical of the Flying-V project, saying that passengers will feel like they're on a roller coaster. Because passengers are seated far from the centre line of the plane, they will experience higher G forces when the plane turns. This will particularly affect economy-class passengers as they are seated further back and at the sides.

Vos thinks it will not be too bad. "Airbus has already done some research on this aspect, putting people in a simulator. Passengers had no problems up to 11 or 12 metres from the centre line. We're keeping within this distance."

An important issue is how quickly passengers can exit the plane in an emergency. All passengers need to be out of the plane within 90 seconds, but there are only half the usual number of emergency exits. "We still need to test this", says Vos. "We don't need the real plane for this; we can experiment using test subjects in a mock-up space with the same format. We may have to make changes to the design to comply with the evacuation requirements, but I don't anticipate this being a show stopper." <<

In the workshop, Malcolm Brown is assembling the plane step-by-step.

TEXT: JOS WASSINK PHOTO: SAM RENTMEESTER

‘The Nederlands will really need a thorium reactor’

According to Jan-Leen Kloosterman, the Netherlands needs nuclear power to reduce CO_2 emissions. Last summer, he led a conference in Delft on a new type of nuclear reactor: the thorium reactor. The professor of reactor physics thinks the Netherlands should invest in a prototype.

Professor Jan-Leen Kloosterman: “There’s not much research funding for nuclear fission in Europe.”

Nuclear power is a thorny issue in Europe. Germany turned away from nuclear energy after Fukushima, but its use of coal-powered plants has led to a rise in carbon emissions. France sees no problem using nuclear power, but its reactors are a half a century old. And the joint problem of everlasting nuclear waste is passed on to future generations.

So you’d think there’s every reason for Europe-wide development of safer nuclear reactors and solutions

for nuclear waste. But that's not how it works, explains Jan-Leen Kloosterman, Professor of Reactor Technology at the Faculty of Applied Sciences and leader of European research programmes on nuclear energy: "There's not much research funding for nuclear fission in Europe." Europe is investing strongly in the ITER experimental fusion reactor with a budget of at least 20 billion euros, but none of that money is available for a prototype Molten Salt Fast Reactor (MSFR).
Why? EU research funds may not initiate research lines themselves, but follow investments of member states. This is why Kloosterman feels the Netherlands should invest €200 million in a prototype thorium reactor (see box).

Virtual reactor

Kloosterman calculated that to achieve the desired carbon-free electricity supply by 2050, the Netherlands needs to get around 10 percent of its electricity from nuclear power. Nuclear power would be the basis supply, supplemented by solar and wind energy as available. "The government seems to be putting all its trust in sun and wind", says Kloosterman. "Or they aren't taking their own climate policy seriously, and are keeping fossil-fuel plants as back-up." So according to him, to achieve a stable power supply without fossil fuels, the question is will we stick with the existing reactor technology, or develop something better?

> The joint problem of everlasting nuclear waste is passed on to future generations

All the researchers who visited Delft last July for the conclusion of the Samofar research programme (Safety Assessment of Molten Fast Reactor, 2015-2019) are convinced that the thorium reactor is a better choice (see box). As chair of the programme, Kloosterman feels that much was accomplished, given the limited budget of around 4 million euros.
The research will continue in the next EU research programme, Samosafer (2019-2023). The plan is to develop physical models for melting and solidifying salt (the heat transporter in the reactor), for the radiant heat released, and for the design of the freeze plug that acts as a safety valve should the reactor overheat. The plug would then melt and the molten salt drain out of the reactor core, stopping the nuclear reaction.
The end product of the research, that has been running since 2010, is a complete software package that simulates the reactor in great detail, particularly under extreme conditions to guarantee the safety at all times.

Practical research

Both Kloosterman and Dr Danny Lathouwers (who led the research on potential accidents with the MSFR) feel that when the project ends in four years, it will be high time for practical research.
Just like the researchers in the SINAP laboratory in Shanghai, they want to build a small prototype MSFR, at an estimated cost of €200 million.
Isn't that a lot of money for a small country? Kloosterman doesn't think so, and points to Belgium that is investing € 500 million for its special Myrrha reactor that is suitable for splitting long-lived nuclear waste.
If the government decides to support the development of a thorium reactor, he thinks a small prototype could be ready by 2030. A rough timeline could then be: a demonstration reactor by 2040 and a European commercial thorium reactor operational by 2050. This would then probably be just what is needed to stabilise the electricity grid. <<

Why a thorium reactor?

At the heart of the design is a Molten Salt Fast Reactor (MSFR). This is a highly modified design of the reactor that ran for thousands of hours in the 1960s in the Oak Ridge Lab in the USA. In the modernised French design, the core of the reactor is a two-metre high and wide steel cylinder filled with molten salt and uranium (U-233) as fissile fuel.
The heat produced in the reactor (around 750 degrees Celsius) is carried by heat exchangers to steam turbines (to generate electricity).
In the CNRS (Centre National de la Recherche Scientifique) design, the reactor functions at ambient pressure, so there is no risk of explosion. Thorium itself is not a fissile material, but when bombarded with neutrons, it transmutes to U-233, which is a fissile material. So fissile fuel is bred from thorium on the outside of the reactor.
Fission products (poisons) are continually removed from the molten salt. After ten years, most of these are hardly radioactive any longer, and a small amount (around 20%) needs to be stored for 300 years. Compare this to the geological storage facilities needed for the current nuclear waste.

IN PERSON

Aukje Hassoldt MSc is the new dean of the Faculty of TPM. She studied physics at VU Amsterdam. She has worked at Rijkswaterstaat, RIZA, TNO and RIVM and is chair of the Dutch Network for Risk Management.

Prof. **Margot Weijnen** (Process & Energy Systems Engineering) will be joining the executive board of NWO. She will be chair of the Domain Applied and Engineering Sciences.

Dr **Norbert Kalb** (QuTech) has been awarded the Stevin Hoogendijk Prize from the Batavian Society. He showed that entangled quantum bits communicate faster than the speed of light. This finding underpins the development of a safe quantum network, on which work will soon begin.

Prof. **Boudewijn Lelieveldt** (EEMCS), Prof. **Catholijn Jonker** (EEMCS) and Prof. **Ibo van der Poel** and Prof. **Sabine Roeser** (TPM) received a total of €56.5 million in Gravitation Grants from the Ministry of Education, Culture and Science for their programmes Brainscapes, Hybrid Intelligence and Ethics of Socially Disruptive Technologies. This will allow the researchers to carry out top-quality research for 10 years.

Five Delft researchers – **Daan Brinks, Arjen Jacobi** and **David Vermaas** of TNW and **Tim Taminiau** and **Menno Veldhorst** of QuTech – have been awarded a European Starting Grant, enabling them to set up a research group early on in their careers.

Hiberband, an innovation of the Hiber company founded by alumnus **Coen Janssen**, has been named one of the three 'National Icons of the Netherlands'. Hiberband reads all kinds of sensors and applications via its own satellite network. It has a larger global coverage than GSM, WiFi and Bluetooth combined. Previous winners included QuTech (2014) and Blue Energy (2016).

COLUMN

Crazy paving

It happened so gradually that I hardly noticed, until a visitor pointed it out to me. "Your paving slabs are in a bit of a state. Subsidence?" I suddenly saw my front garden through his eyes and he was right, it was turning into an obstacle course of uneven slabs.

Heel Holland Zakt was the title of an article on subsidence written a couple of years ago by science journalist René Didde for *de Volkskrant* newspaper, about the ground beneath our feet. An article with a sobering message. The wettest areas of the Netherlands will sink by up to 84 cm this century; the land is sinking faster than the sea level is rising.

Peat oxidises and reduces in volume when exposed to air. This can be prevented by having a higher water table, but the farmers don't want this, because if their meadows get too waterlogged, their tractors get stuck in the mud.

So the water table is kept low and the land continues to sink, which, in addition to peat oxidisation, leads to extra greenhouse gas emissions.

In *Heel Holland Zakt*, experts came up with all kinds of creative solutions, from lightweight cattle which cause less soil compaction, to floating housing estates.

We urgently need to think outside the box, but the question is whether the proposed innovations will be in time.

It has been remarkably dry in the Netherlands for a considerable time, resulting in a low water table and extra subsidence problems. The KCAF, a knowledge centre for building foundation problems, warned this year that one million houses are under threat.

According to a report by *RTL Nieuws* news channel, houses built before 1970 are particularly at risk: one in four faces potential subsidence. The cost for home owners can be as much as 100,000 euros.

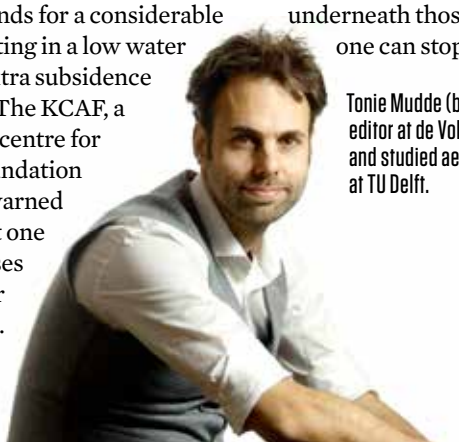
I think my house was built before 1970. I know I don't have 100,000 euros to spare. And my paving slabs are uneven.

On the way to the builders merchants for some sharp sand to level things out again, I tried to stay calm. Of course the KCAF would say there are huge foundation problems; it's in the interests of any knowledge centre to give extra emphasis to its own specialist problem area. Just imagine the knowledge centre for foundations saying 'subsidence, no problem, these foundations are fine for another hundred years'; they would put themselves out of a job right away.

Anyway Mudde, don't get all worked up! - uneven paving slabs don't mean there's something wrong with your house. The house is built on piles, there are no cracks in the walls and all the doors and windows open and shut smoothly.

Back from the builders merchants, I lift the paving slabs one by one, spread and compact the sharp sand and replace the slabs.

A job well done - as smooth as a billiard table. For the time being, because there's something going on underneath those slabs that no-one can stop...



Tonie Mudde (born 1978) is science editor at de Volkskrant newspaper and studied aerospace engineering at TU Delft.

THE FIRM

With the experience they gained with the Solar Boat Team, three former TU Delft students launched Flying Fish, a maritime innovation company. Their advice? "If your employees enjoy their work, that motivates you, too."

Gijsbert van Marrewijk and his Flying Fish co-founders first met when they were members of TU Delft's Solar Boat Team. They want to make water transport an efficient and sustainable alternative to land transport by applying the Solar Boat's hydrofoil technology to commercial boats. Using their simulation software, HOST, they can calculate and test which hydrofoil is suitable for which boat. "With a hydrofoil a boat floats above the water and you use up to 60% less fuel," says Van Marrewijk. "Our Solar Boat, which had the power of two domestic kettles, reached a speed of 50 km/h."

Travellers will be able to use an app to book a watertaxi

Van Marrewijk obtained his Master's in space systems engineering in 2018. His co-founders, brothers Gerben and Johan Schonebaum, studied Aerospace Engineering and High-Tech Engineering. Their fourth partner, Olivier Prakken, comes from outside TU Delft and is an experienced entrepreneur. "Olivier taught us a networking course. We got talking and asked him for advice. He ended up being our fourth founding partner." Flying Fish was officially launched in December 2018.

Thanks to Prakken's business experience, the company was able to attract a major partner straight away: the watertaxi in Rotterdam. Van Marrewijk: "We showed them our hydrofoil, but what they wanted was software to help them plan taxi rides more efficiently. As an engineer, you think, too bad, we'll come back in a few years' time. But Olivier saw opportunities."

Flying Fish started work on a second product: the Watertaxi Operations System. Using data analytics, they study the shipping lanes and the occupancy levels of the boats. Tim Visser works on that full time: "The watertaxi has a huge set of data. They didn't know how much of it was useful. Now we are developing a software system to use the boats as efficiently as possible. Travellers will be able to use an app to book a watertaxi."

Most of the company's other employees work part time: they are former members of the Solar Boat Team who work for Flying Fish a few days a week alongside their Master's degree. "As an entrepreneur, you realise that it's your responsibility to create a good working atmosphere," says Van Marrewijk. "If our employees enjoy their work, that motivates me, too."

Creating his own orders is Van Marrewijk's biggest challenge. "When you approach a company you hope they'll say: 'come up with a hydrofoil with these specifications'. It doesn't work like that. You have to tell them a good story, so that you get the order you want and that is most beneficial to the customer. That's different from university, where a lecturer knows exactly what to ask of his students." MdH

Company Name:	Flying Fish
	Gijsbert van Marrewijk, co-founder and Tim Visser, employee
Degree Programme:	Aerospace Engineering
Products:	Watertaxi Operations System and HOST Draagvleugel Simulator
Founded in:	2018
Employees:	Five full-time (including three founders) and six part-time employees
Turnover:	Estimated €150,000 – €200,000 in 2019
In five years' time:	6 million passengers using water taxis or hydrofoil boats that use their innovations

Photo: Sam Rentmeester

Gijsbert van Marrewijk (r) and Tim Visser.

Working together with companies and institutions

'TU Delft demolishes last wall between science and industry' headlined Het Financieele Dagblad in February. No need to worry, TU Delft continues to be a place for research and education, while increasing collaboration with businesses to accelerate innovation. President of the Executive Board Tim van der Hagen explains.

TEXT: AGAATH DIEMEL PHOTO: DANIEL VERKIJK

"In February we launched X!Delft, a new programme in which we are working together with large companies and financial institutions. Not on specific projects, as often happened in the past in the form of contract research, but in a broader sense: can new technologies lead to new products or business models? And based on our philosophy that what we do should have a positive impact for a better society, for example working with Heineken on circular production, and with VolkerWessels on reducing their carbon footprint."

Field labs

"This launch was behind the headline in the Het Financieele Dagblad newspaper. However, X!Delft is just one of the ways in which we are expanding our collaboration. Last year, we signed an agreement with Ahold Delhaize to explore the use of robotics in the retail branch. And in recent years we have set up a considerable number of field labs. These include the Autonomous Shipping Research Lab, a meeting place for all parties involved in autonomous shipping – researchers, business partners and government authorities. And The Green Village, our open-air lab where we are working on solutions to flooding in the city and testing whether hydrogen could be a good alternative to natural gas."

Medical collaboration

"Our medical research is conducted in close collaboration with our fellow universities in Leiden and Rotterdam. This can be seen on campus at HollandPTC, the proton therapy research and treatment centre that we set up together with Erasmus MC and the LUMC. And last year we strengthened the bonds with Erasmus MC and Erasmus University Rotterdam (EUR) even more, to enable us to combine medicine, technology and social sciences in order to tackle complex issues in the field of health and healthcare."

Incubators

"Activity on the campus is steadily increasing as well. Our incubators Yes!Delft and Yes!Delft Labs offer a place for dozens of innovative start-ups with their roots in TU Delft know-how. And with success: last year, Yes!Delft was in second place in the world rankings for University Business Incubators. Together with the ASR Dutch Science Park Fund, we are now exploring the possibilities for creating a collective building for scale-ups from Yes!Delft and other businesses who would like to settle on campus. Companies such as Applikon Biotechnology, VSL, Exact and 3M led the way, and will soon be joined by electrical multinational ABB."

'Encounter is an important aspect of the innovation process; meeting with other people that can lead to inspiration, cross-pollination and new collaborations'

Co-creation

"We are turning into a University 4.0: an innovation ecosystem in which we work together with businesses, government bodies and other knowledge institutions to accelerate valorisation of our research in the market and society. This is vital, because challenges such as the energy transition, shortages of raw materials, traffic congestion, rising sea levels and sinking groundwater levels are extremely urgent. The old model, in which research results may or may

Professor Tim van der Hagen welcomed 'business' residents into the TU Delft community.

not have been developed further in industry or business, is no longer fit for purpose. That innovation chain takes too much time, and too many ideas and inventions never make it to final application. This is why nowadays we seek each other out and work jointly and simultaneously, rather than alongside and after each other. It is precisely this co-creation that accelerates innovation."

TU Delft Campus

"To reinforce this development, we have decided that the entire university grounds, including the former Technopolis site should continue under a single name: TU Delft Campus. I can hear you thinking, OK so the TU Delft campus is now called TU Delft Campus. Yet this is an important step. The physical difference is that the former Technopolis site is now also part of the TU Delft campus. But far more important is that it shows that we are welcoming our 'business' residents into the TU Delft community: a single community joined by technology and the joint passion to realise sustainable innovations."

Encounter

"This development was formally celebrated on 20 September with a kick-off attended by over 300 people from every corner of the campus: students, researchers and field lab assistants, start-ups, scale-ups and large companies. And this was just a beginning, because encounter is an important aspect of the innovation process; meeting with other people that can lead to inspiration, cross-pollination and new collaborations. I myself had to leave the celebrations a little early. An hour later, I was seated together with Minister Van Engelshoven in the front row at the awarding of the Gravitation grants, the government funding for consortia of excellent academics who are carrying out innovative and influential research in their field. After all, research will always be core business at TU Delft."

The future

"And what will our campus look like in ten or twenty years' time? I suspect, a cross between a traditional campus and a high-tech industrial park. But still a place where we continue to provide excellent teaching and carry out fundamental and applied research; and at the same time a place where we are all building together on the future, with a focus on our mission: impact for a better society. One thing is certain: there will always be a place on campus for our alumni, because you are also a vital part of the TU Delft ecosystem. There's a good reason why we say 'TU Delft for life'." <<

‘Pride is the most important thing for alumni’

Nienke Maas is senior energy transition consultant at TNO, and in her work she still has regular contact with TU Delft. She can also often be found on campus; she is a member of the board of the Delft University Fund. “It’s great to see the university’s commitment in its communication with alumni.”

TEXT: AGAATH DIEMEL PHOTO: GUUS SCHOONEWILLE

Nienke Maas was always fascinated by the built environment. “Even when I was a child, travelling in the car with my parents, I wondered how bridges or viaducts were built.” Civil engineering was an obvious choice. “I was attracted by the visibility: you’re not working on something minuscule in a lab, but on infrastructure that people use every day.”

Collective solutions

At TNO, she has spent more than 20 years working on complex urban issues. “Right now I’m working on the energy transition, a major issue that will have a huge impact on the built environment. It’s relatively easy to make 10 houses energy-neutral, but what if we have to scale up current solutions for entire housing estates? This requires smart collective solutions, but we also need to have a clear picture of how our electricity system as a whole should function,” she explains. “At the same time, technology is advancing. Three years ago, hydrogen wasn’t even being discussed; now there are a few pilots with ‘green’ hydrogen. It would be much easier to heat houses with it, because then not all houses would have to be insulated. But when will this technology actually be safe to use? And do we have enough hydrogen for low-grade heat applications? Maas believes in action-oriented research, in which solutions are tested in practice and evaluated scientifically at the same time. “However, we don’t have the time or the money to experiment with a hundred techniques in a hundred different places. As such, it’s a complex problem that research institutes, energy companies, housing corporations and municipalities have to tackle together.”

Finding consensus

Collaboration is key. In The Hague, Maas recently led a project involving all these stakeholders in the energy transition. “That was mainly about increasing mutual understanding. Municipalities, for example, are given a great deal of responsibility by the government; they then have to talk

The university could make much more use of its alumni and their networks’

with residents. This includes tough discussions and negotiations, but it starts with being mindful of each other’s – often conflicting – interests,” she says. “Which is nothing new. Five

Nienke Maas: "Through the University Fund we want to contribute to the excellence of TU Delft."

hundred years ago, we also had to find consensus to protect the country from flooding. The energy transition is all about consensus and that's in our DNA."
"To solve complex social issues, we need to bundle a lot of multidisciplinary and design knowledge," says Maas. Both TNO and TU Delft are good at that. She first discovered that years ago when supervising graduates. "I was struck by the fact that TU Delft is such a design-driven, solution-oriented university. Delft students don't start with hypotheses, but they look for specific solutions. You can still see that, for example, in the Dream Hall, where students from all faculties work together on their projects with tremendous drive and ambition: they keep going until it works."

Commitment

Maas still has regular contact with TU Delft, for example as part of joint research projects or when drawing up recommendations on energy innovations. For the past 12 years or so, she has also been actively involved at the university as an alumnus. "I joined the board of the former alumni association. At the time, it was still separate from the Delft University Fund." She is now a board member of the DUF. "I try to ensure there is as much continuity as possible in the contact between alumni and the university. It's great to see the university's commitment to this." She believes it's best to build these contacts while the students are still studying. "In the first few years after graduation, I mainly kept in touch with study friends; the university itself wasn't really relevant. It's the same for people I know. They don't feel like an alumnus and it's only when their children go to secondary school that the university pops up again." As a member of the alumni panel, Maas helps the University Fund decide how to communicate with alumni. "We act as a sounding board and advise, for example, on how the TU Delft can approach alumni. The university could make much more use of its alumni and their networks. You can find out what alumni think about things like integrity or new technologies, which then helps to stimulate the social debate," she says.

Continuity

This contact can also be beneficial to alumni. "Alumni like to be kept informed about the university's research and they are interested in ground-breaking new knowledge. Some also use TU Delft to keep their knowledge of their field up to date as part of lifelong learning." Yet Maas believes that pride in your alma mater is perhaps the most important thing for alumni. "Through the University Fund we want to contribute to the excellence of TU Delft. As an alumnus, you benefit from having studied at a leading university. Positive reports about the university also reflect well on alumni. There's a lot for alumni to be proud of, but pride is just like trust: it takes years to build and seconds to break. So continuity in communication is also vital for that." <<

Are you inspired by this story and would you like to find out how you can continue to be involved at TU Delft? Then we'd love to hear from you! Send an email to: alumnirelations@tudelft.nl.

ALUMNI NEWS

Alumni Activities

30 October
Karel Luyben Lecture London

7 November
Alumni Event Hamburg

14 November
Alumni Backstage Tour Robotics

17 November
Alumni Event Genève

23 November
Virgiel reunion

Sign up on the alumni community platform tudelftforlife.nl or on the alumni.tudelft.nl website.

Get in touch

Questions, comments or ideas?
Email: alumnirelations@tudelft.nl
Website: alumni.tudelft.nl
Community: tudelftforlife.nl

'TU Delft for Life' is the online community for all TU Delft alumni. Expand your network, meet your old university peers and stay up to date on the latest news and events. Sign up on tudelftforlife.nl. You can also change your contact details and communication preferences there.

Karel Luyben Lecture London | 30 October

The Delft University of Technology is delighted to announce that this year's Karel Luyben Lecture will take place at the Royal Institution in London on Wednesday 30 October 2019, and will be given by Dr Eline van der Kruk. In this lecture, Alumna Eline van der Kruk will introduce you to the world of biomechanics, where computer simulations and smart sensors are used to push the boundaries of human movement.
These lectures were instigated in honour of Karel Luyben on the occasion of his farewell as Rector Magnificus. They are organised once a year in Delft and once a year somewhere in the world. The lectures bring together two subjects Karel Luyben has always been passionate about: talented young scientists, and involving local communities in science. In addition to the lecture, the event is also a special gathering of alumni, students and all those fond of TU Delft and its research. **alumni.tudelft.nl/events**.

How to get scientific articles after graduation

Quit some alumni want to keep access to the research and articles published in the academic world, however they cannot access through the former student credentials after graduation. In honour of alumni that want to keep reading publications, Alumni Relations made an overview of all the different ways of getting access to literature. You can find all the information on: **alumni.tudelft.nl/getthearticle**.

CAN ALGAE REPLACE THE CARCINOGENIC CHROMIUM-6?

Extraordinary things are happening in Dr Santiago Garcia's laboratory at the Faculty of Aerospace Engineering. His research group is working on new solutions for existing problems in the field of aircraft materials. The group is currently achieving great success using algae in the development of a safe and environmentally friendly corrosion protector to replace the carcinogenic chromium-6. An own algae nursery can speed up this research.

WILL YOU HELP?

Check www.universiteitsfondsdelft.nl/algae

> 'WHEN WE USE ALGAE TO MAKE SUSTAINABLE CORROSION PROTECTORS, ALL KINDS OF STRUCTURES – AIRCRAFT, TRAINS, TANKS – CAN BE PROTECTED WITHOUT THE NEED TO USE TOXIC AND EXPENSIVE MATERIALS'
>
> Dr Santiago García

DO YOU WANT TO JOIN US AT THE 2019 TASTE OR EXCELLENCE DINNER?

(Photo: Roy Borghouts)

Become a Good Friend and meet the best of TU Delft

The annual Taste of Excellence Dinner is the festive conclusion of the TU Delft Best Graduate Award Ceremony, taking place on 12 November 2019. Good Friends and the Best Graduates of TU Delft dine together with scientists, the Board of TU Delft and other special relations and are thanked for their special engagement with the university and Delft University Fund.

Good Friends support Delft University Fund through a 5 year (fiscally attractive) donation agreement with a minimum annual donation of 500 euro. This way, Good Friends structurally help realise the ambitions of TU Delft in the field of education, research and talent development. Team up With Excellence!

Become a Good Friend before 31 October 2019 and you will receive a personal invitation. For more information, please contact: Machteld von Oven, Relationship Management & Development.
M.W.VONOVEN@TUDELFT.NL or WWW.UNIVERSITEITSFONDSDELFT.NL/FRIENDS

The lab of...

Cognitive Robotics (3mE)

For his Master's thesis, Stefan Bonhof (vehicle engineering) is working on 'knowledge-based robot control' at the Cognitive Robotics department. The robot in the photo is a so-called 'mobile manipulator' – a robot arm (with hand) on a mobile platform. Bonhof programs the robot to recognise objects and their uses unaided. The robot knows what cups, glasses, beakers, etc. are, what they (can) look like, and what you can do with them (pouring liquid in or out). The robot also has a general knowledge of the best way to pick up these items and perform tasks with them. The robot uses this information to work out how to perform a new task in a new environment.

PHOTO: SAM RENTMEESTER